A Plan for Adaptive Management Studies for the Stanislaus River Basin

Project Information

1. **Proposal Title:**

   A Plan for Adaptive Management Studies for the Stanislaus River Basin

2. **Proposal applicants:**

   Doug Demko, S.P. Cramer & Associates, Inc.

3. **Corresponding Contact Person:**

   Doug Demko
   S.P. Cramer & Associates
   PO Box 247 Mi Wuk Village, CA 95346
   209 586-5020
   demko@dcs-chico.com

4. **Project Keywords:**

   At-risk species, fish
   River Basin Management
   Salmon/Steelhead Biology

5. **Type of project:**

   Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   At-Risk Species Assessments

8. **Type of applicant:**

   Private for profit

9. **Location - GIS coordinates:**

   Latitude: 37.753

   Longitude: -121.001

   Datum:

Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

The geographic scope of the project extends from the upstream anadromous fish barrier, Goodwin Dam (RM 58.4), on the Stanislaus River to the confluence with the San Joaquin River.

10. **Location - Ecozone:**

    13.1 Stanislaus River

11. **Location - County:**

    Stanislaus

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    Yes

    If yes, please list the city: City of Oakdale

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    18

15. **Location:**

    California State Senate District Number: 12

    California Assembly District Number: 25

16. **How many years of funding are you requesting?**

    3

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

       No

       If no, list single overhead rate and total requested funds:

       Single Overhead Rate: 0

       Total Requested Funds: 212,220

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

No

Have you previously received funding from CALFED for other projects not listed above?

No

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

No

Have you previously received funding from CVPIA for other projects not listed above?

Yes

If yes, identify project number(s), title(s) and CVPIA program.

11332-9-j010	**Evaluate the use of radio-tagged juvenile chinook salmon to identify cause and location of mortality**	**AFRP**
11332-0-M007	**Juvenile salmon outmigration monitoring at Caswell**	**AFRP**
Funds direct from BOR	**Evaluation of Smolt Survival**	**AFRP (Funds Direct from Burea of Reclamation)**

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

Please list suggested reviewers for your proposal. (optional)

21. **Comments:**

Environmental Compliance Checklist

A Plan for Adaptive Management Studies for the Stanislaus River Basin

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No
   b) Will this project require compliance with NEPA?

      No
   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      The proposed project is planning only and does not constitute an action that will require NEPA/CEQA compliance.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   CEQA Lead Agency: none
   NEPA Lead Agency (or co-lead:) none
   NEPA Co-Lead Agency (if applicable): none

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      Not Applicable

   b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

#5. The proposed project is developing a model and does not require any permits.

Land Use Checklist

A Plan for Adaptive Management Studies for the Stanislaus River Basin

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   The proposed project is planning only.

4. **Comments.**

Conflict of Interest Checklist

A Plan for Adaptive Management Studies for the Stanislaus River Basin

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Doug Demko, S.P. Cramer & Associates, Inc.

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

Carl Mesick Carl Mesick Consultants

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

Steve Cramer S.P. Cramer & Associates

Ray Beamesderfer S.P. Cramer & Associates

Doug Demko S.P. Cramer & Associates

Andrea Phillips S.P. Cramer & Associates

Comments:

Budget Summary

A Plan for Adaptive Management Studies for the Stanislaus River Basin

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

Independent of Fund Source

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Develop a conceptual model	440	28680	720	1600	600	10400	0	0	42000.0	0	42000.00
2	Evaluate hypotheses with existing information	480	32400	800	1400	600	13000	0	0	48200.0	0	48200.00
3	Conduct an outside review of theconceptual model	0	0	0	0	0	15000	00	0	15000.0	0	15000.00
4	Prioritize research and restoration actions	280	23240	560	800	300	7800	0	0	32700.0	0	32700.00
5	Develop and maintain web site	240	10080	320	300	1000	0	0	0	11700.0	0	11700.00
		1440	94400.00	2400.00	4100.00	2500.00	46200.00	0.00	0.00	149600.00	0.00	149600.00

Year 2												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
5	Develop and maintain web site	120	5040	160	150	800	0	0	0	6150.0	00	6150.00
6	Public Outreach	200	12840	360	400	1000	2600	0	0	17200.0	0	17200.00
7	Revise and update the conceptual model	176	14608	352	600	400	5200	0	0	21160.0	0	21160.00
		496	32488.00	872.00	1150.00	2200.00	7800.00	0.00	0.00	44510.00	0.00	44510.00

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
5	Develop and maintain web site	120	5040	160	150	800	0	0	0	6150.0	0	6150.00
7	Revise and update the conceptual model	96	8168	192	600	400	2600	0	0	11960.0	0	11960.00
		216	13208.00	352.00	750.00	1200.00	2600.00	0.00	0.00	18110.00	0.00	18110.00

Grand Total=212220.00

Comments.

Budget Justification

A Plan for Adaptive Management Studies for the Stanislaus River Basin

Direct Labor Hours. Provide estimated hours proposed for each individual.

Total project hours for each employee class are estimated as follows: Technician 680 Biologist I 320 Biologist II 440 Biologist III 560 Senior Consultant 152 Task 1 will require 160 technician, 40 Bio I, 80 Bio II, 120 Bio III, and 40 Senior Consultant hours. Task 2:160 tech, 40 Bio I, 80 Bio II, 160 Bio III, 40 Senior Consultant Task 4: 40 Bio I, 80 Bio II, 120 Bio III, 40 Senior Consultant hours Task 5: 320 tech, 160 Bio I Task 6: 40 tech, 40 Bio I, 80 Bio II, 40 Bio III Task 7: 120 Bio II, 120 Bio III, 32 Senior Consultant

Salary. Provide estimated rate of compensation proposed for each individual.

The amounts listed for salary are SPCA's billing rates minus the benefit rates listed below. The billing rates include actual pay rates plus all overhead for each category of employee for each hour worked. Besides the employee pay and benefits, the billing rate includes costs associated with operation of the company such as Project administration (invoicing, payroll, et.), office rental, electricity, basic phone charges, internet connections, copy machine rental, employee taxes, company insurance for office and equipment, office supplies and furniture, salary employee bonuses, all overhead associated with each employee (disability insurance, workman's comp, vacation pay, holiday pay, etc.),company truck lease, etc. The following rates apply to the each category of employee listed in the project: Technicians $34/hr Bio I $58/hr Bio II $68/hr Bio III $93/hr Senior Consultant $108/hr $Principal Scientist $123/hr The actual employee pay is approximately 45% of the above billing rates plus the benefits listed below.

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

Technicians receive $1/hr for insurance and all other categories receive $2/hr for insurance.

Travel. Provide purpose and estimate costs for all non-local travel.

Total travel costs are expected to be approximately $6,000. This includes travel to and from meetings in a rented truck.

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

The total cost of supplies and expendables is expected to be $5,900. This total can be broken down as follows: communication (long-distance/field crew phones) $100/month= $3,600 computing (website software, domain name, etc.) $900 office supplies for document prep., copies, toner, binding,etc. $1400

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

The billing rate for consultant hours is $65/hour. The following is a break-down of hours by task. Task 1. Development of model: 160 hours Task 2. Evaluation of hypothesis: 200 hours Task 4. Prioritization of actions: 120 hours Task 6. Public outreach: 40 hours Task 7. Revising of model: 120 hours Task 5. Outside statistical review of model is estimated to cost $15,000, but specific reviewers have not been identified at this point.

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

There will not be any equipment purchased for this project.

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

The Project Management aspects are incorporated into each of the tasks by Bio II and III. Reports and presentations are presented as tasks in the project. The cost to administer the contract is included in the billing rates.

Other Direct Costs. Provide any other direct costs not already covered.

No other direct costs are anticipated at this time.

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

All indirect costs are included in the billing rates and are explained in detail above under salaries. The billing rates include salary + benefits.

Executive Summary

A Plan for Adaptive Management Studies for the Stanislaus River Basin

 The purpose of this three-year project is to assist the Stanislaus Fish Group in the development of a consensus-based plan to guide research and restoration to benefit salmonids in the lower Stanislaus River, below Goodwin Dam. The Stanislaus Fish Group consists of agency biologists from the Department of Fish and Game, Department of Water Resources, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, National Marine Fisheries Service, and U.S. Army Corps of Engineers, as well as consulting biologists representing the local water districts and those conducting restoration and studies in the Stanislaus River for CALFED and the Anadromous Fish Restoration Program. The basis of the plan is the development of a conceptual model that summarizes the beliefs/hypotheses and supporting knowledge regarding the decline of fish populations in the lower Stanislaus River. The Stanislaus Fish Group would work cooperatively to develop a list of hypotheses regarding the presumed sources of mortality for each life history stage of chinook salmon, steelhead trout, and rainbow trout. This approach will incorporate the various beliefs of the resource managers, scientists, and stakeholders into sets of alternative hypotheses about how the Stanislaus Rivers ecosystem functions, how it has been altered or degraded, and how various actions might improve the system. S.P. Cramer and Associates, Inc. (SPCA) and Carl Mesick Consultants (CMC) would then gather and evaluate all existing information to evaluate each set of hypotheses to the extent possible. Existing sources, such as the CALFED White Papers, a Draft Candidate Conservation Agreement by SPCA, a soon-to-be-released existing conditions report for the Stanislaus River by EIP Associates, and a limiting factors analysis for the Stanislaus River conducted by CMC, would provide the foundation for the database. Workshops would be held so the Stanislaus Fish Group could direct SPCA and CMC in the refinement of the conceptual model. An outside review would then be conducted to further refine the model. The next step would be to develop a plan for adaptive management studies that prioritizes management issues and recommends either targeted research, demonstration restoration projects, or full-scale implementation projects to address each issue. To assist the Fish Group with the prioritization process, a simple quantitative population model will be developed with parameters derived from the hypotheses in the conceptual model. The ability to game with the model will serve two useful functions. First, it will allow the Fish Group to identify key uncertainties by comparing the possible response of fish populations to the alternative hypotheses in the conceptual model. Second, it will help show how fish populations might respond to different stressors and restoration actions. Although this process will probably highlight the differences in the beliefs held by the various members of the Fish Group, the result will be a plan that fully describes the management issues so that adaptive management experiments can be designed to evaluate all of the alternative hypotheses. In many cases, it is anticipated that the Fish Group will recommend study and restoration methods to ensure that the issues are resolved to everyones satisfaction. During the second and third years of this project, new information will be evaluatedand if necessary, the conceptual and quantitative models, recommended actions, and priorities will be revised. To facilitate the initial development and ongoing revisions of the plan, a web site will be created where the plan and all supporting information will be posted. This will provide all members of the Stanislaus Fish Group with immediate access to the latest version of the plan and new information.

Proposal

S.P. Cramer & Associates, Inc.

A Plan for Adaptive Management Studies for the Stanislaus River Basin

Doug Demko, S.P. Cramer & Associates, Inc.

A Plan for Adaptive Management Studies for the Stanislaus River Basin

A. PROJECT DESCRIPTION: PROJECT GOALS AND SCOPE OF WORK

A.1. PROBLEM

Although resource managers throughout the Central Valley desire to pursue the optimum track to ecosystem restoration, there is low confidence that we know what the optimum track is for any particular watershed. A fully functioning ecosystem is a complex jigsaw puzzle to assemble, and most resource managers are not aware of the full suite of studies completed for the various pieces. There is no ready reference system for the continually emerging scientific evidence, nor for past studies, that managers can use to make informed decisions. Further, resource managers generally do not share a common vision for how available information should be interpreted, nor how integration of the pieces into a whole picture should proceed. These problems in discerning the optimum track for ecosystem restoration arise from several factors: (1) the mental energies of resource managers tend to be consumed by the specific area and factors for which they have responsibility, while ecosystem function extends across multiple scientific disciplines and management jurisdictions; (2) past studies that relate to some aspect of ecosystem function were generally only designed to resolve a specific issue for a specific interest group at a specific time and place, (3) although resource managers are interested in communicating with and learning from one another, the process is difficult, because there is no entity responsible for assembling and coordinating the exchange of information; and (4) there has been no focused effort to develop a shared conceptual model for how the various pieces of information should be related to one another to interpret ecosystem function.

The challenge posed by having multiple jurisdictions each pursuing independent goals for management of aquatic resources, is perhaps as great in the Stanislaus Basin as in any watershed of the Central Valley, and it is in the Stanislaus Basin that we propose a program that will overcome these problems of splintered resource management. This program will provide rapid access and synthesis to existing information on salmonids and their habitat in the Stanislaus River, develop a shared conceptual model for information processing, provide staff and analytical tools to foster collaboration between jurisdictions, and provide adaptive management of restoration efforts. The purpose of this project is to develop a shared and accurate vision among fishery biologists for an optimum approach to restoring salmonid populations within the anadromous fish zone. There are substantial populations of chinook salmon and rainbow/steelhead in the lower Stanislaus Basin, and the high public interest in these species make them a good choice to use as indicators of ecosystem health. Flows in the Stanislaus River, which is the northern most major tributary to the San Joaquin River, are highly regulated by New Melones Dam, which is part of the Central Valley Project. Historically, 113 miles of the river were available to anadromous fish, and now access is limited to the

lower 58 miles of river below Goodwin Dam, which was built in 1913.

Fisheries biologists from state and federal governments, local irrigation districts, and independent CALFED/AFRP contractors have been meeting as the ad hoc "Stanislaus Fish Group" (hereafter Fish Group) since 1997. The purpose of the group is to provide technical advice, including review and synthesis of Stanislaus River fisheries data, to stakeholders and others to guide research and restoration efforts. The groups effectiveness is limited by the lack of synthesized data for the river and not having the tools (e.g. basin life-history model) to identify important data gaps and limiting factors, and guide research and restoration actions. Several different parties have or are currently conducting research on the Stanislaus River, however, the results are not available in a way that synthesis can easily occur. Synthesis of information and data would help identify limiting factors to increasing production, and ultimately double the annual escapement (AFRP Goal).

The Fish Group has substantial expertise and historical knowledge of fisheries investigations in the basin, but is lacking funding for several key activities and tools which would provide scientific justification for future research and restoration actions. Cooperatively, Fish Group members identified the following challenges that this proposal will help overcome:

1. The Fish Group needs tools that foster information sharing and consensus building to enable the group to provide more active, consensus-based guidance to watershed participants.

2. The Fish Group needs technical tools and assistance to enable the group to provide science-based guidance for future research and restoration actions.

3. The Fish Group needs to compile all information relating to the Stanislaus River and make sure that existing information is identified, preserved for historical purposes, and immediately available to all watershed participants.

4. The Fish Group needs to synthesize existing data on salmon and trout populations, and their habitat, and build on the insights gained.

5. The Fish Group needs to increase project collaboration to achieve a shared understanding of limiting factors and a synergistic approach to restoration activities.

6. The Fish Group needs to develop a process which enables the group to adaptively manage salmon and trout populations.

Existing Studies

Numerous studies of fish populations, stream conditions, and stream processes have been conducted over the years, and many studies continue on behalf of Tri-Dam Project, South

San Joaquin and Oakdale Irrigation Districts, USFWS, CDFG, USBR, USACE, CALFED, and Stockton East Water District. A recent synthesis for much of the biological information was assembled in a Draft Candidate Conservation Agreement (Cramer and Demko 1998). More recently, Mesick (2001) completed a correlative analysis of limiting factors for chinook populations in the basin. These two reports summarize a substantial portion of fish and habitat studies in the basin. Following is a summary of key studies in the basin below Goodwin Dam that will be useful in developing a shared conceptual model of salmonid life-history:

Salmonid Biology

- Annual Spawning Surveys by CDFG
- Annual Estimates of Juvenile Out-Migrants
- Survey of Gravel Use by Chinook Spawners
- Radio tracking of Out-migrant Behavior
- Snorkel Surveys of Juvenile Salmonid Rearing
- Fish Species Composition in the lower River (Brown 1998)

Physical Studies

- Temperature Modeling
- Water Management Model
- Gravel Quality for Spawning and Egg Incubation
- Reconnaissance of Fluvial and Geomorphic Processes

We identified the following working hypotheses which have helped us identify specific project objectives and tasks:

< Substantial basin information and data exists which is not being utilized by basin managers because its existence is unknown. Location, synthesis, and dissemination of this information will allow us to make better management decisions and will ensure that current and future managers are working with the best available scientific information.

< Further identification and synthesis of existing data within the Stanislaus Basin is needed to identify trends, habitat use, and factors affecting trends in salmonids. Significant data sets exist for the basin, and they need to be fully exploited to better understand trends and limiting factors for salmon and rainbow/steelhead that are key to the region. First, however, a reliable database of information must be created.

< Creation of an on-line Stanislaus River database will improve coordination among managers and ensure that all managers have access to and are working with the same data. By locating and summarizing this information we will save substantial effort and money by increasing efficiency preventing future redundant efforts.

< Studies by independent groups can be more effectively coordinated to address

information needs in the broader context of population limiting factors and ecosystem function.

< Resource managers can be better informed about findings from the diverse set of studies that have already been completed, and this knowledge can be used for consensus-based management decisions.

< Resource managers can develop a shared vision for interpreting salmonid life-history information and how it influences populations and what it indicates about ecosystem function.

< A salmonid life-history model will provide substantial benefits for current and future managers, including a shared understanding of salmonid life-histories, identification of information gaps, and a tool for evaluating the relative value of proposed actions. Development of the model will provide a detailed accounting of the times, locations, and variables for which information are needed.

< Better management decisions will be made if managers collaborate to optimize future research, management, and adaptive decision making.

The goal of this project is to:

Synthesize basin information and develop a life-history model to help manage salmonids in the Stanislaus River Basin and optimize effectiveness of investment toward ecosystem restoration.

In order to achieve this goal, three objectives must be accomplished:

1. Develop a Shared Information Base
2. Develop a Shared Conceptual Basin Salmonid Life-History Model for Information Processing
3. Develop a Process and Tools for Collaboration and Adaptive Management of Restoration Efforts

A.2. JUSTIFICATION

The Ecosystem Implementation Plan identifies a need to integrate the existing information on salmonid life histories into conceptual models that consider the animals' use of widely varying habitats, from the upper river through the Delta, into the ocean and back to the river. Presently, there are no conceptual models that have been proposed or completed by scientists in the Stanislaus River Basin. Multiple Region priority MR-6 of the ERP Implementation Plan points out the need for integrated interdisciplinary knowledge that can be used for conceptual models, describing existing and restored ecosystems in each stream.

Our concept of why the project proposed here will succeed centers on the idea that before a shared and accurate conceptual model can be developed, there must be a fully shared information base (Figure 1). Before there can be a fully shared information base, there must be (1) a compilation and synthesis of currently available information into a readily digestible form, and (2) a forum for thoroughly communicating that information to the basin biologists. One reason a shared conceptual model has not been achieved, is that these precursor steps have been inadequately addressed.

This proposal was developed at the direction of the Fish Group and represents the collective thought processes of most of the members (Fish Group members who are also on the CalFed review committee were excluded from the process). The proposal is intended to meet the immediate information and management needs of the basin, as identified by the group, by providing information and resources to help the group identify and prioritize restoration needs, and provide a decision making framework which will aid adaptive management.

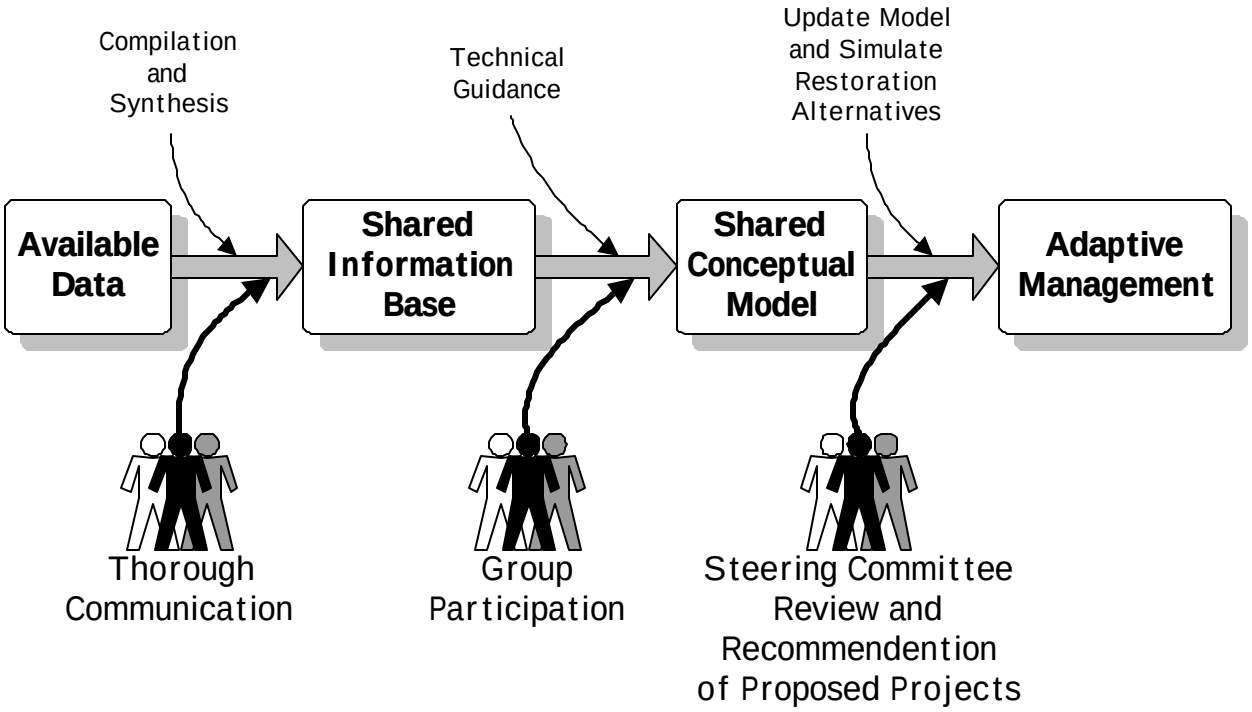

Figure 1. Steps for integrating information into a conceptual model that can be used as a tool for adaptive management.

A second challenge to overcome in developing a shared conceptual model is the difficulty of getting all members of a group to understand a very complex concept. This challenge can be overcome by providing the group with a guide that has been down the path of developing a full conceptual model before. The guide (a biologist-modeler) can lead the group through examples of organizing concepts that have already been developed for other basins. This will enable the group to build on a foundation of substantial work already completed in this science arena.

Finally, the group must have free choice and an active role in deriving the appropriate model for their watershed. Group involvement in development of the model and their opportunity to chose its form are necessary for them to develop a shared sense of ownership. Without this final step, preceded by (1) development of a shared information base, and (2) guidance through organizing concepts that can be helpful, it is unlikely that any diverse group of biologists in a watershed can arrive at a widely shared conceptual model.

The justification for this project does not stop here, but follows through with application of the conceptual model to the adaptive management process, just as envisioned in the ERP Implementation Plan. The Plan's diagram of the Adaptive Management Process (Figure 1, p. 8 of the Plan) indicates that assessment of restoration actions will lead to possible revisions in restoration goals and objectives, or in components of the conceptual model, and these revisions will be processed through the conceptual model to determine how restoration actions should be modified. Likewise, this project provides for updating the conceptual model and assisting the group in running simulations to determine how restoration actions should be modified.

This project will improve the understanding of at-risk species (ERP Priority SJ-4) by providing a review panel and steering committee (Stanislaus Fish Group) for ongoing and proposed projects. Efforts are needed to improve standardization among researchers of monitoring techniques, data compilation and analysis, and reporting (Strategic Goal 1, At-Risk Species Assessments).

Use of the Conceptual Model

The development of a detailed conceptual model for the Stanislaus River that relates our knowledge of fish to ecosystem function is a centerpiece in the discussion of the ERP Implementation Plan. That Plan states,

> "*The knowledge and hypotheses about ecosystem structure and function summarized in conceptual models can lead directly to potential restoration actions. ..Conceptual models help to shape the character of restoration actions by identifying key uncertainties or by revealing the level of confidence at which a particular action will achieve a given objective.*"

The Implementation Plan acknowledges that different scientists may have different conceptual models of ecosystem function, and the purpose of this project would be to develop an accurate conceptual model that reflects the range of beliefs of the basin biologists of how ecosystem function relates to salmonid production. The effort would be accomplished as a demonstration project in the Stanislaus Basin, and the pattern followed, plus much of the modeling accomplished, could be transferrable to other basins of the Central Valley.

Perhaps the most important justification for this project is the support of the Stanislaus Fish Group, the entity that originally identified the need for the model. The group, a collection of agency and private consultants with many years of experience on the Stanislaus River, unanimously supports the need for this work. Many members of the group participated in the development of this proposal through conference calls and draft reviews.

A.3 APPROACH

The purpose of this project is to develop a consensus-based plan to guide research and restoration to benefit salmonids in the Stanislaus River. The project has three objectives. First, it will develop a shared information base. Second, it will develop a shared conceptual model of existing information and the beliefs/hypotheses of all biologists working on the Stanislaus River regarding how the Stanislaus River ecosystem functions, how it has been altered or degraded, and how various actions might improve conditions in the system. Third, it will develop a process and tools for collaboration and adaptive management of restoration efforts. These objectives will be achieved by implementing seven tasks described below.

Task 1. Develop Conceptual Model.

SPCA and CMC will develop a framework for a conceptual model based on the CALFED White Papers, a Draft Candidate Conservation Agreement by SPCA (Cramer and Demko 1998), an existing conditions report for the Stanislaus River (EIP Associates, in press), and a limiting factors analysis for the Stanislaus River conducted by CMC (Mesick 2001). Using this framework, the Fish Group would work cooperatively to develop a full list of hypotheses regarding the sources of mortality and habitat associations for each life history stage. Two models will be developed: One for chinook salmon and the other for steelhead and rainbow trout. Where Fish Group members have differing opinions regarding how the ecosystem functions, how it has been altered or degraded, and how various actions might improve conditions in the system, those differences will be developed into a set of alternative hypotheses. By developing a set of alternative hypotheses for each issue, future proposals for research or restoration can be designed to evaluate the full range of beliefs held by the various Fish Group members. The hypotheses will be revised as the supporting evidence is evaluated (Task 2) and as new information is obtained (Task 6).

Task 2. Evaluate Hypotheses with Existing Information.

SPCA and CMC would gather and analyze all existing information to evaluate the hypotheses in the conceptual model. In addition to studies on salmonids, information would be sought from studies that evaluated physical processes related to the formation of stream habitat, including present distribution and quality of in-channel and flood-plain habitat, temperature, hydrologic regime, sediment supply, and riparian vegetation. Both the oldest and newest studies would be included, including research reports, key memorandums, and white papers. If no data exist for the Stanislaus River for a particular issue, general ecological principals and results from studies conducted on the Tuolumne, Merced, and other Central Valley rivers will be considered. This task would build upon work already completed and funded by SSJID, OID, Tri-Dam, SEWD, AFRP, and CalFed. We believe that most key reports on fish and ecosystem function in the basin are known to one or more members of the Stanislaus Fish Group, so our information search will begin by querying each group member to determine the available reports. The raw data, data computations, and statistical analyses used to evaluate each hypothesis will be presented in the report describing the conceptual model. SPCA will maintain a library of fish and stream habitat studies used to develop the conceptual model that would be available to all Fish Group members and biologists working on the Stanislaus River (Task 4).

After SPCA and CMC have completed the initial evaluation of the conceptual model, a series of workshops would be held so that the entire Fish Group could direct SPCA and CMC in the refinement of the conceptual model. When appropriate, revised drafts of the model would be distributed by e-mail for comment.

Task 3. Outside Review.

After the Fish Group is satisfied with the draft conceptual model, an external panel of experts will be assembled for a review. Potential reviewers include Dr. Michael Healey, Dr. Charles Hanson, and Dr. Matt Kondolf. The Fish Group will hold workshops to incorporate the review panel's comments.

Task 4. Prioritize Research and Restoration Actions.

A plan for adaptive management studies will be developed that prioritizes the management issues and recommends either targeted research, demonstration restoration projects, or full-scale implementation projects to address each issue. To assist the Fish Group with the prioritization process, a simple quantitative population model will be developed with parameters derived from the hypotheses in the conceptual model. The model will be run in a spreadsheet format that can be projected on a screen with a laptop computer. This will allow the Fish Group to watch the model manipulation and output as it occurs. The ability of the Fish Group to "game" with the model with serve two useful functions. First, it will help identify key uncertainties by comparing the possible response of the fish population to the alternative

hypotheses in the conceptual model. Second, it will help show how the fish population might respond to different stressors and restoration actions. By highlighting the uncertainties and differences in the beliefs held by the various members of the Fish Group, this process will ensure that the plan fully describes the management issues and recommends adaptive management experiments that evaluate the entire set of alternative hypotheses. In many cases, it is anticipated that the Fish Group will recommend specific study and restoration methods to ensure that the issues are resolved to everyone's satisfaction.

Task 5. Develop and Maintain Web Site.

A central location for the documents we use and create during our analysis is needed to provide real-time information readily available to everyone. We will register the domain name www.stanislausriver.com and then construct a web page. The adaptive management plan and conceptual model will be posted in electronic formats, such as Word and WordPerfect, that can be easily edited and resubmitted to the Fish Group for consideration. Important historical documents will be converted to electronic format (PDF) and stored on the website to form an electronic library.

Developing and maintaining the website is not crucial to complete this project, however elimination of this task will not reduce the project price. Elimination of the website will decrease efficiency and increase the costs associated with all other tasks such that the project would actually be more costly. For example, without the website all documents and data would have to be transmitted via e-mail or regular mail. It would be extremely costly to distribute all information to all participants this way, and many would be receiving duplicate copies of information they already have. It is much more efficient to post updates to a website, where participants can have access to all information as needed.

Task 6. Public Outreach

After the conceptual model and adaptive management plan are satisfactory to all members of the Fish Group, a meeting will be held in Knights Ferry to explain the model and plan to the public and to provide instructions for how to obtain information from the web site and to submit comments. The meeting will be publicized in the local newspapers, including the Oakdale Leader and The (Stockton) Record, to encourage attendance.

Task 7. Revise and Update the Conceptual Model.

In addition to our real-time management approach employed throughout the year, each summer modeling assistance staff will work with the Fish Group and stakeholders to integrate the previous year's results into a revised plan for the upcoming year. We envision a three-step process each summer to 1) review past years results, 2) interpret results and integrate information into the basin life-history model, and 3) to develop written monitoring and management strategies for fall, winter, and spring operations. Although we will strive for real-

time adaptive management throughout the year, this summer review period will ensure that at least annually we collectively review information learned during the previous year and incorporate it into a revised strategy for the upcoming year. Summer is an ideal time for this intensive review and planning process because data collection and field research activities surrounding the previous adult spawning run and their offspring are complete, and field activities for the next adult migration will not start until late September. Thus, the summary, review, and planning process will be completed between June and August.

4. FEASIBILITY

The information gathering and model building can certainly be completed, because we have completed such tasks in other basins, and we are aware that as much data exist on fish and stream habitat in the Stanislaus Basin as we have in other basins where we completed this work. The biggest question is whether we can achieve the level of shared understanding and vision among biologists that is intended by this project. Our strongest evidence that such common ground can be achieved is that this proposal is supported by the Stanislaus Fish Group, for whom we would work to build the shared conceptual model. Further, our team includes Dr. Carl Mesick, a consultant with many years of experience in the basin, including several CalFed projects. Dr. Mesick has extensive modeling experience and will play an integral part in the development and ongoing use of the basin conceptual model.

SJ-4 “Projects should continue to identify Central Valley salmonids life history and habitat associations and requirements. A priority focus for these efforts should be to build knowledge of the status and needs of steelhead in the San Joaquin Region (Strategic Goal 1, At Risk Species Assessments).”

5. PERFORMANCE MEASURES

The performance measures used to assess the project’s success in relation to its objectives include development of a detailed synthesis of existing data, an internet site with data and reports identified, the basin conceptual model including extensive supporting material, and an adaptive management plan that includes recommendations for future research and restoration. The Fish Group will oversee all aspects of the project, such that there will be ongoing evaluation of the procedures and any necessary changes can be made during the course of the project.

During the project we will distribute, via e-mail, meeting announcements, meeting notes, monthly progress reports, and all work products as they are completed. All of our physical work products, including data and results of the scale reading, will also be posted on the internet on a real-time basis.

At the end of the study, we will prepare a technical report detailing our results. The report will be distributed to participating agency biologists via hardcopy and will be made available

to the public via our website.

6. DATA HANDLING AND STORAGE

Data files, reports, the conceptual model and the adaptive management plan will be made accessible on a near real-time basis to agency personnel, watershed management groups, and the public via a web site. Consistent data file formats will be applied among years to provide for accurate and efficient use of the information. Hard copies of all information posted to the website will be maintained at SPCA's Central Valley office in Oakdale.

7. EXPECTED PRODUCTS AND OUTCOME

The expected outcome of this project will be an adaptive management plan and basin conceptual model with supporting evidence that will be useful for designing and selecting high priority research and restoration projects for the Stanislaus River.

8. WORK SCHEDULE

We propose to begin work in September 2002 and complete the project in August 2005. Table 1 presents the proposed annual work schedules for the duration of the project.

Table 1. Proposed annual work schedules.

Project Year	Task	Start Date	Completion Date
Year 1	Task 1. Develop model	Sep. 2002	Dec. 2003
	Task 2. Evaluate hypotheses	Jan. 2003	Mar. 2003
	Task 3. Outside review	Mar 2003	May 2003
	Task 4. Prioritize actions	May 2003	Aug. 2003
	Task 5. Website	Sep. 2002	Aug. 2003
Year 2	Task 5. Website	Sep. 2003	Aug. 2004
	Task 6. Public outreach	Sep. 2003	Dec. 2003
	Task 7. Revise and update	Jun. 2004	Aug. 2004
Year 3	Task 5. Website	Sep. 2004	Aug. 2005
	Task 7. Revise and update	Jun. 2005	Aug. 2005

B. APPLICABILITY TO CALFED ERP AND SCIENCE PROGRAM GOALS AND IMPLEMENTATION PLAN AND CVPIA PRIORITIES

1. ERP, SCIENCE PROGRAM AND CVPIA PRIORITIES

This project will help achieve the CALFED ERP, Science Program, and Anadromous Fish Restoration Program goals to improve our understanding of at-risk species, such as fall-run chinook salmon, in the San Joaquin region, to advance the understanding of ecosystem processes, and to assist the design of adaptive management experiments. The process of summarizing the existing information regarding mortality factors for each life history stage in the Stanislaus River and the development of a conceptual model will help to advance our understanding of the interactions between at-risk species and ecosystem processes. The adaptive management plan will assist the design of research and restoration in the Stanislaus River and thereby improve the ability of agency biologists to manage the ecosystem.

2. RELATIONSHIP TO OTHER ECOSYSTEM RESTORATION PROJECTS

This project will utilize the results from other research and demonstration projects on the Stanislaus River that are either in progress or planned.

S.P. Cramer and Associates received CVPIA funding (AFRP and B2) for juvenile salmon outmigrant sampling on the Stanislaus River at Caswell State Park from 1997 through 2001. Funding was also received from the AFRP in 1999 for an evaluation of the use of radio-tagged juvenile chinook salmon to identify cause and location of mortality, and from B2 in 1999 for an evaluation of smolt survival in the Stanislaus River.

CMC, with assistance from McBain and Trush, Smith and Walser Enterprises, and other subcontractors, will begin implementing a large-scale restoration project on the Stanislaus River in 2002 that will investigate the importance of restoring functional floodplain habitat adjacent to restored riffle habitat. The Anadromous Fish Restoration Program will fund work at Two-Mile Bar where both the floodplain and riffle habitat will be restored. The Four-Pumps Mitigation Agreement will fund work at Lovers Leap where riffle habitat will be restored but the floodplain will remain heavily encroached with riparian vegetation and constricted by dikes. CMC and Smith and Walser Enterprises will design the riffles to benefit both fall-run chinook salmon and steelhead trout. They will also conduct studies to evaluate the hypothesis that steelhead trout require cover and feeding stations adjacent to their spawning habitat. McBain and Trush will conduct fluvial geomorphic studies to evaluate the effect of a functional floodplain on sediment transport at the restored riffles.

CMC is submitting a proposal titled the Frymire Ranch Project to CALFED in September 2001 that will increase the scope of the above project. By increasing the number of restoration sites, the environmental studies will be strengthened by increasing the number of replicates and it is hoped that it will be possible to detect a population response in terms of increased smolt production and increased escapement.

SPCA, CMC, CDFG, and Smith and Walser Enterprises are submitting a proposal to CALFED in September 2001 to study the impact of predation on salmonid production in the Stanislaus River. The restoration of riffle habitat in dredged channels is probably reducing the abundance of predators based on reports from professional fishing guides. This proposed project would demonstrate the effect of restoring riffle habitat on predation rates and identify the most important predators and their habitat.

The U.S. Fish and Wildlife Service has contracted with the Fisheries Foundation to survey juvenile and adult salmonid habitat use in the Stanislaus River in 2000 and 2001. This study indicated that numerous juvenile chinook salmon and juvenile rainbow/steelhead trout were utilizing the KFGRP riffles constructed in summer 1999 whereas few juveniles were observed in the channels mined for gravel. It is anticipated that this study will continue.

CALFED funded CMC to implement the Knights Ferry Gravel Replenishment Project that added 13,000 tons of gravel at 18 sites between Two-Mile-Bar and the city of Oakdale in summer 1999. This project tested the source, size and placement of gravel for spawning habitat. The results of the KFGRP were used to design this project.

The Commercial Fishermen Salmon Stamp Program funded the Stanislaus Fly Fishermen and the Department of Fish and Game to add 1,000 to 2,000 tons of gravel each year to three sites in the Stanislaus River approximately one mile downstream from Goodwin Dam in 1996 and 1997. The CVPIA Section 3406(b)(13) program provided funds to add more gravel to one site in 2000.

The Four-Pumps Mitigation Agreement funded the construction of three riffles as spawning habitat for chinook salmon in the Stanislaus River at River Miles 47.4, 50.4 and 50.9 in 1994. These riffles were poorly used by spawning salmon and most of the gravel was quickly eroded away partially due to the boulder weirs constructed at the site boundaries. The weirs were intended to stabilize the gravel, but instead increased turbulence and bed shear stress.

3. REQUESTS FOR NEXT PHASE FUNDING

No request for next phase funding.

D. PREVIOUS RECIPIENTS OF CALFED PROGRAM OR CVPIA FUNDING

S.P. Cramer and Associates received CVPIA funding (AFRP and B2) for juvenile salmon outmigrant sampling on the Stanislaus River at Caswell State Park from 1997 through 2001. Funding was also received from the AFRP in 1999 for an evaluation of the use of radio-tagged juvenile chinook salmon to identify cause and location of mortality, and from B2 in 1999 for an evaluation of smolt survival in the Stanislaus River.

CMC received funding for the Knights Ferry Gravel Replenishment Project, #97-N21, which

added 13,000 tons of clean gravel to 18 sites on the Stanislaus River from Two-Mile Bar to the city of Oakdale in August 1999. This project is expected to be completed in December 2001.

CMC has just executed a contract (#11332-1-J003) with the AFRP for "Spawning Habitat and Floodplain Restoration in the Stanislaus River at Two-Mile Bar, Phase 1. Work is expected to begin in fall 2001.

CMC is in the process of contracting with the California Department of Water Resources for Four-Pumps Mitigation Agreement funding for the project called "Spawning Habitat and Floodplain Restoration in the Stanislaus River at Lovers Leap. Work is expected to begin in summer 2002.

E. SYSTEM-WIDE ECOSYSTEM BENEFITS

This project will greatly facilitate the development and review of proposals to implement research and restoration in the lower Stanislaus River. It should also be useful for adaptive management planning for other watersheds.

F. ADDITIONAL INFORMATION FOR PROPOSALS CONTAINING LAND ACQUISITION

The proposed project does not involve land acquisition.

3. QUALIFICATIONS

Key Personnel:

Doug Demko, a Fisheries Biologist and Juris Doctor, will manage and coordinate the proposed project activities within SPCA and between the cooperating parties, and will supervise data collection and analysis, public outreach activities, model development, and interpretation and report preparation activities. Doug has worked in the Central Valley since 1990. He has led a variety of field sampling projects and has gained the respect of state and federal fisheries biologists as an expert in migrant fish sampling. His experience in the Sacramento-San Joaquin system is extensive, and includes leading research projects such as screw trapping, smolt survival studies, radio tracking, predator surveys, resident trout population estimates, habitat surveys, and limiting factors analyses. Additionally, he recently obtained a law degree which has furthered his understanding of water law and endangered species issues. The trust, respect and understanding of the issues he has gained by representing both stakeholders and the resource agencies, equips Doug with the skills to facilitate communication between diverse participants.

Andrea Phillips will coordinate and supervise field personnel and data collection activities and assist in data analysis and report preparation. Andrea has worked in the Stanislaus Basin since 1995 and grew up in Oakdale which has allowed her to develop both personal and

professional relationships with landowners, concerned community members, recreational groups, researchers, educational institutions and many other watershed partners. Since 1995 she has assisted Doug in the coordination of field research activities on the Stanislaus River and other tributaries to the San Joaquin River which has required considerable networking and coordination with state, federal and local government personnel, private consultants, landowners and recreational groups. Her contacts within the basin and her knowledge of Stanislaus River research and recreational activities are an invaluable asset to the project.

Ray Beamesderfer will oversee the development of the basin life-history model. Ray received his MS in fishery resources from the University of Idaho in 1983 and has since conducted original research and analyzed applied problems of fish biology. He has extensive experience with salmon, steelhead, sturgeon, warmwater sportfish, and nongame species; has published numerous scientific articles on fish sampling, population dynamics, and species interactions; and has special expertise in the use of statistics and computer modeling to solve difficult fish questions. He recently joined us from the Oregon Department of Fish and Wildlife where he analyzed Columbia River fish and fishery information to forecast runs, regulate sport, commercial and Treaty Indian fisheries, and assess Endangered Species impacts and risks.

Carl Mesick will be the lead fisheries biologist to develop the Stanislaus River basin conceptual model. Carl received his Ph.D. in fisheries science from the University of Arizona in 1984. He has twenty years of experience as a fisheries scientist evaluating the effects of water diversions, hydroelectric operations, stream restoration projects, timber harvest, and mine operations on trout, salmon, non-game species of fish, and invertebrates. Dr. Mesick's expertise includes stream habitat restoration and studies of instream flow, water temperature, riparian vegetation, sedimentation, entrainment at diversion intakes, food availability, fish passage, fish habitat preference, fish population monitoring, and stream habitat classification. He has studied the spawning habitat of fall-run chinook salmon on the Stanislaus River since 1994. Dr. Mesick manages and supervises all phases of the Knights Ferry Gravel Replenishment Project funded by CALFED, including project design, environmental compliance and permitting, construction supervision, and the monitoring of salmonid spawning habitat. Dr. Mesick worked as a Habitat Restoration Coordinator for the U.S. Fish and Wildlife Service's Anadromous Fish Restoration Program in 1998 and 1999.

Corporate Qualifications:

S.P. Cramer & Associates, Inc. (SPCA) was established in 1987 to provide innovative problem solving on issues relating to salmon and trout on the Pacific Coast. We are reputed for our investigative work in determining why fish populations have or may change in response to specific actions. The core of the firm is composed of three Senior Fisheries Consultants, each with over 20 years of noteworthy experience. Our support staff includes a Biologist Project Leader, four Biologist Assistant Project Leaders, a Computer Applications Specialist, a Statistician, a Fisheries Facilities Engineer, a GIS specialist and a seasonal staff of 10 to 18 Fisheries Technicians.

SPCA has been conducting research within the Sacramento-San Joaquin Basin for public and private water rights holders, CAMP, and AFRP since 1990, and are therefore very familiar with basin issues, key watershed participants, and the actions necessary to conduct the proposed project. SPCA has conducted numerous fisheries investigations, monitoring and assessments in the Sacramento-San Joaquin basin. Past and on-going fisheries work include, but are not limited to annual monitoring of juvenile chinook outmigration, adult migrant trapping, radio tracking and electrofishing, analyses of hatchery contribution rates and a status review of west coast steelhead.

Carl Mesick Consultants (CMC), which was founded in 1992, has extensive experience with river restoration and the Stanislaus River. CMC has three projects to restore spawning and floodplain habitat on the Stanislaus River that are funded by CALFED, the AFRP, and the Four-Pumps Mitigation Agreement. On behalf of the Stockton East Water District and the Stanislaus River Council, a coalition of environmental organizations, CMC evaluated the streamflow and habitat requirements of fall-run chinook salmon and steelhead in the Stanislaus River from 1994 to 1998. CMC also assisted with the design, supervision, and monitoring of the restoration of brown trout habitat in lower Rush and Lee Vining creeks, Mono County, California on behalf of California Trout, Mono Lake Committee, Audubon Society, California Department of Fish and Game, and Los Angeles Department of Water and Power from 1992 to 1994. For the U.S. Forest Service, CMC helped design watershed restoration plans for the Eldorado National Forest to minimize the impacts of erosion from logging roads, skid trails, and grazing practices.

D. COST

1. Budget.

The total cost for this 3 year project as proposed is $212,220. All tasks are necessary to complete this project.

2. Cost-Sharing.

Cost share funds have not been secured for this project, however it is important to note that the project will utilize the resources of the existing Stanislaus Fish Group. The expert opinions and data provided by group members will be incorporated into the model thereby increasing its accuracy and power for guiding future projects in the basin. All data used for the creation and revision of the model are collected under separate funding.

E. LOCAL INVOLVEMENT

The Stanislaus Fish Group, which consists of agency and consulting biologists active on the Stanislaus River, has expressed a need for an adaptive management plan as proposed here. The Fish Group will direct all phases of this project. The public will be encouraged to

participate in the plan development through a public meeting and the use of a web site.

F. COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

The proposed project has been developed in compliance with all of CalFed's standard terms and conditions presented in Attachment D of the August 2001 PSP. The applicant has reviewed and will comply with CalFed's terms and conditions. The applicant also understands that the contract terms will apply to any sub-contracts that may be entered into to complete the proposed work. There are no conflicts of interest in performing this work.

G. LITERATURE CITED

Brown, L.R. 1998. Assemblages of fishes and their associations with environmental variables, lower San Joaquin River drainage, California. Report prepared in cooperation with the National Water-Quality Assessment Program by the U.S. Geological Survey. Open-File Report 98-77. Sacramento, CA.

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