An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

Project Information

1. **Proposal Title:**

   An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

2. **Proposal applicants:**

   David Vogel, Natural Resource Scientists, Inc.

3. **Corresponding Contact Person:**

   David Vogel
   Natural Resource Scientists, Inc.
   P.O. Box 1210 Red Bluff, CA 96080
   530 527-9587
   dvogel@resourcescientists.com

4. **Project Keywords:**

   Fish mortality/fish predation
   Fish Passage/Fish Screens
   Water Resource Management

5. **Type of project:**

   Research

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

   No

7. **Topic Area**:

   Diversion Effects of Pumps

8. **Type of applicant:**

   Private for profit

9. **Location - GIS coordinates:**

Latitude:	39.190
Longitude:	-121.934
Datum:	NAD27

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

Sacramento River between the confluence with Stony Creek to the North and the confluence with the American River to the South.

10. **Location - Ecozone:**

    3.4 Colusa to Verona, 3.5 Verona to Sacramento

11. **Location - County:**

    Colusa, Glenn, Sacramento, Sutter, Yolo

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    Yes

    If yes, please list the city: Sacramento

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    3

15. **Location:**

    California State Senate District Number: 4, 6

    California Assembly District Number: 2, 8, 5

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

    2

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: 40

       Total Requested Funds: $458,506

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?

Yes

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

ERP-01-N48	**Juvenile Salmon Migratory Behavior Study in the North, Central, and South Delta**	**ERP**
Unknown	**Delta Cross Channel Studies**	**Unknown**

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.

Report Title: Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne Rivers	**AFRP**
Report Title: Juvenile Chinook Salmon Radio-Telemetry Study in the Northern Sacramento-San Joaquin Delta, January-February 2000	**AFRP**

Report Title: Juvenile Chinook Salmon Radio-Telemetry Study in the Southern Sacramento-San Joaquin Delta, December 2000-January 2001		**AFRP**
2001-K203	**Merced River Water Temperature Management Feasibility Study**	**AFRP**
FWS Agreement #113320J027	**Merced River Wing Dam Monitoring, 2000-2002**	**AFRP**

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:**

    17a: Overhead is 40% of charge-out rate. 17c: Because specific diversion sites will not be known until after the project is initiated, we do not know which landowners, if any, may cost share in the project.

Environmental Compliance Checklist

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

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.

      This is an evaluation project.

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

   CEQA Lead Agency:
   NEPA Lead Agency (or co-lead:)
   NEPA Co-Lead Agency (if applicable):

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.**

Land Use Checklist

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

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).

   This is a research only project.

4. **Comments.**

Conflict of Interest Checklist

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

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):

David Vogel, Natural Resource Scientists, Inc.

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

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

Sue Sutton	Family Water Alliance
None	None
None	None
None	None
None	None

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

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

David Vogel	**Natural Resource Scientists, Inc.**
Keith Marine	**Natural Resource Scientists, Inc.**

Comments:

Budget Summary

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

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	Inventory and Categorize Types of Diversions	192	7278	1456	3400	2183	0	0	3250	17567.0	5822	23389.00
2	Develop an Outreach Program with Landowners to Participate in the Project	0	0	0	0	0	41819	0	0	41819.0	0	41819.00
3	Measure Site-Specific Physical Features of Small Diversions by Type of Diversion	320	9235	1847	5500	2770	0	0	9925	29277.0	7388	36665.00
4	Quantify Fish Entrainment for Each Diversion	1572	25110	5022	16000	7533	0	0	28750	82415.0	20088	102503.00
5	Project Management	480	15756	3151	4727	0	0	0	0	23634.0	12605	36239.00
		2564	57379.00	11476.00	29627.00	12486.00	41819.00	0.00	41925.00	194712.00	45903.00	240615.00

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**
1	Inventory and Categorize Types of Diversions	0	0	0	0	0	0	0	0	0.0	0	0.00
2	Develop an Outreach Program with Landowners to Participate in the Project	0	0	0	0	0	39023	0	0	39023.0	0	39023.00
3	Measure Site-Specific Physical Features of Small Diversions by Type of Diversion	320	9512	1902	5500	2853	0	0	9925	29692.0	7610	37302.00
4	Quantify Fish Entrainment for Each Diversion	1572	25866	5173	16000	7760	0	0	28750	83549.0	20693	104242.00
5	Project Management	480	16228	3246	4868	0	0	0	0	24342.0	12982	37324.00
		2372	51606.00	10321.00	26368.00	10613.00	39023.00	0.00	38675.00	176606.00	41285.00	217891.00

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**
		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Grand Total=458506.00

Comments.

Budget Justification

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

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

YEAR 1 Principal Investigator: 416 Fishery Biologist: 416 Field Biologist: 612 Field Tech: 1040 Data Entry/Clerical: 80 YEAR 2 Principal Investigator: 320 Fishery Biologist: 320 Field Biologist: 612 Field Tech: 1040 Data Entry/Clerical: 80

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

YEAR 1 Principal Investigator: $48.91/hour Fishery Biologist: $26.90/hour Field Biologist: $17.45/hour Field Tech: $13.28/hour Data Entry/Clerical: $16.88/hour YEAR 2 Principal Investigator: $50.38/hour Fishery Biologist: $27.70/hour Field Biologist: $17.98/hour Field Tech: $13.68/hour Data Entry/Clerical: $17.38/hour

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

Principal Investigator: 20% of salary Fishery Biologist: 20% of salary Field Biologist: 20% of salary Field Tech: 20% of salary Data Entry/Clerical: 20% of salary

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

Travel entails field site visits and includes mileage, fuel, lodging and meals. Estimated cost for both years: $55,995

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

All supplies & expendables pertain to field supplies. Estimated cost for both years: 23,099.

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.

Family Water Alliance would be involved in Task 2 - Develop an Outreach Program with Landowners to Participate in the Project. In Year 1 they would provide a Community Liason for 64 days at $294.20/day and a Program Manager for 28 days at $821.03/day. In Year 2 they would provide a Community Liason for 52 days at $311.22/day and a Program Manager for 28 days at $815.67/day.

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.

None.

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.

Project management tasks and associated costs (based on percentage of time) for both years include: reporting requirements ($14,713), report preparation ($22,069), project meetings ($11,034) and overall project oversight ($25,747).

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

YEAR 1 50 Fyke nets at $500 each: $25,000 ADCP Rental: $3,000 Underwater Video Rental: $250 25 GO flow meters at $150 each: $3,750 25 thermographs at $150 each: $3,750 Jet Boat Rental & Fuel: $6,175 YEAR 2 50 Fyke nets at $500 each: $25,000 ADCP Rental: $3,000 Underwater Video Rental: $250 25 GO flow meters at $150 each: $3,750 25 thermographs at $150 each: $3,750 Jet Boat Rental & Fuel: $2,925

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.

Overhead rate is 40% of charge-out rate and includes workers compensation, office rent, phones, commercial general liability insurance, state disability insurance, utilities, computer hardware and software, furniture, office equipment and supplies, accounting payroll, and unbillable labor of support staff.

Executive Summary

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

Fish passage protection at water diversions in the Sacramento River basin has been and remains a high priority for both CALFED and CVPIA programs. Large investments have been committed to constructing or renovating fish screens for most of the largest diversions on the Sacramento River. The CVPIA's Anadromous Fish Screen Program has facilitated fish screen development and demonstration projects for screening of smaller agricultural diversions since 1993. The CALFED ERP has spent more than $80 million on fish screen and passage programs. While progress has been made to develop fish screens and screen many small diversions through the Sacramento River Small Diversion Fish Screen Program supported and partially funded by CALFED, large numbers of small agricultural diversions on the middle to lower reaches of the Sacramento River remain unscreened. Criteria for determining any one small diversion's impact on fishery resources have not been universally established. While some detailed information on relative fish losses has been available to guide screening efforts for larger diversions, the technical understanding of impacts of small agricultural diversions remains insufficient to quantify potential fish losses or to quantify benefits to fish populations from screening such diversions. Uncertainty remains as to the impact of small diversions and the benefits to be derived from fish screening. Further, it is not yet fully known what level of benefit-to-cost may be expected from screening diversions of different sizes. Incremental improvements to fish survival resulting from screening projects have not yet been fully evaluated. These circumstances have made it difficult to prioritize allocation of expenditures for screening the numerous remaining unscreened small diversions. Through a systematic process we propose to evaluate the factors outlined in our conceptual model for small diversions on the middle and lower Sacramento River in order to identify criteria that can be used to determine the severity of potential for impact, to determine necessary fish protection and to prioritize diversions to receive fish protection. This program will stratify diversion types based on site-specific characteristics and extrapolate results to other similar types of diversions in the middle and lower Sacramento River. The research for this project is essential to obtain data on unscreened small diversions to facilitate and prioritize future restoration actions for Sacramento River basin anadromous salmonids.

Proposal

Natural Resource Scientists, Inc.

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

David Vogel, Natural Resource Scientists, Inc.

An Evaluation and Prioritization of Small Unscreened Diversions for Fish Protection in the Middle and Lower Sacramento River

A. Project Description: Project Goals and Scope of Work

1. Problem

Fish passage protection at water diversions in the Sacramento River basin has been and remains a high priority for both CALFED and CVPIA programs (USFWS 1995, USBR 1997, CALFED 2001 ERP Draft Stage 1 Implementation Plan). Large investments have been committed to constructing or renovating fish screens for most of the largest diversions on the Sacramento River. The CVPIA's Anadromous Fish Screen Program-Section 3406(b)(21)-(AFRP) has facilitated fish screen development and demonstration projects for screening of smaller agricultural diversions since 1993. The CALFED ERP has spent more than $80 million on fish screen and passage programs (CALFED 2002 PSP). While progress has been made to develop fish screens and screen many small diversions through the Sacramento River Small Diversion Fish Screen Program supported and partially funded by CALFED, numerous small agricultural diversions on the middle to lower reaches of the Sacramento River remain unscreened. Criteria for determining any one small diversion's impact on fishery resources have not been universally established. While some detailed information on relative fish losses has been available to guide screening efforts for larger diversions such as at the Glenn-Colusa Irrigation District and Reclamation District 108 Wilkins Slough diversions, the technical understanding of impacts of small agricultural diversions remains insufficient to quantify potential fish losses or to quantify benefits to fish populations from screening such diversions. These circumstances have made it difficult to prioritize allocation of expenditures for screening the numerous remaining unscreened small diversions.

The most comprehensive empirical evaluation of anadromous salmonid losses entrained into irrigation diversions from the Sacramento River was conducted by the California Department of Fish and Game (CDFG) during 1953 and 1954. In recent years, CDFG conducted some very limited assessment of entrainment into selected agricultural diversions on the main-stem Sacramento River. However, the sampling was too limited to provide quantitative estimates of losses and the data were not published in report format (Frank Fisher, retired CDFG, pers. comm.). Hallock and Van Woert (1959) concluded from intermittent sampling at 23 irrigation diversions in the Sacramento River during the 1953 irrigation season that:

> "Individually, most of the small irrigation diversions do not destroy many young salmon and steelhead. Collectively, however, they take considerable numbers."

The Resources Agency of California reported:

> "Although some information exists on water diversion locations and pumping capacities, detailed data such as diversion construction and intake design/location of each are lacking or not readily available. Studies are needed to identify

> diversions that significantly affect the fishery and to determine the cost of work required to effectively screen each diversion." (RAC 1989)

The Upper Sacramento River Fisheries and Riparian Habitat Management Plan similarly identified the need to determine the minimum size of diversion that significantly affects the fishery and find solutions to the fishery problems posed by small unscreened diversions. Investigation of alternative fish protection methods has also been encouraged for larger diversions, but has received little attention on smaller agricultural diversions. The Resources Agency fully supported that, “Innovative techniques should be studied in an effort to minimize fish losses and maximize screening efficiency in a cost-effective manner."(RAC 1989)

In 1995, the U.S. Bureau of Reclamation (USBR) completed a two-year pilot demonstration program to install fish screens at three sites on the Sacramento River to eliminate entrainment of young salmon into unscreened agricultural diversions. The program was implemented in accordance with the National Marine Fisheries Service (NMFS) Biological Opinion concerning Central Valley Project Operations effects on winter-run chinook salmon which directed USBR to "... develop and implement a demonstration screening program designed to advance the state-of-the-art positive screening barrier technology at small unscreened diversions along the Sacramento River ..." (Spencer Hovekamp, USBR, pers. comm.).

In recent years, the Family Water Alliance and Natural Resources Conservation Service, Department of Agriculture, have demonstrated that their approach to working cooperatively with landowners and other partners on current fish screen projects is both effective and feasible. Through cooperative efforts those entities completed the installation of fish screens at seven diversions: 4 cylindrical screens and 3 Universal Stream Bottom Retrievable flat plate fish screens. Two retractable screens will replace failed cylindrical screens. One retractable screen has been installed and one is currently under construction and will be installed in August. Three of the larger cylindrical screens demonstrated problems during operation due to the interaction of unique river conditions, which include high turbidity, sediment load, and vegetative material. This interaction between the river conditions and the screen resulted in the freezing of bearings, the failure of the self-cleaning mechanisms, the clogging of filters, and the ultimate implosion of screens at two diversion sites. These malfunctions provided invaluable information regarding Sacramento River conditions and the effectiveness of screen operations. Information gained from real world application has contributed to new screens design improvements and screen cleaning systems. The cylindrical screens are scheduled to be replaced with modified screens that incorporate recommended improvements.

Farmers continue to show interest and commitment to the fish screening program. While technology development is often slow and frustrating, numerous farmers have signed up to screen their pumps in spite of the setbacks. Over the past three years the National Marine Fisheries Service, California Department of Fish and Game, and Natural Resource Conservation Service

have demonstrated exemplary cooperation and sensitivity to farmers needs. This spirit of cooperation only furthers the partnership between private landowners and agencies.

There are many small agricultural diversions remaining unscreened and those diversions have an unknown level of impact on Sacramento River anadromous salmonids. Collectively, due the large number of small diversions and the presence of at-risk species inhabiting the Sacramento River, the potential for impact must be better assessed. However, due to the high degree of variation in the design, operation, and site-specific characteristics of these small diversions, the potential magnitude of impact to fishery resources for any given diversion is likely to be highly variable.

We propose to evaluate small agricultural diversions along the middle and lower Sacramento River from approximately the Stony Creek confluence to the American River confluence (Figure 1) based on site-specific physical, hydraulic, and biologic characteristics. We will test the hypothesis that juvenile salmonids are entrained in direct proportion to flow diverted by evaluating a range of conditions at numerous diversion sites. The objective of the evaluation is to quantify site-specific characteristics of small diversions that affect fish entrainment. The goal of this project is to develop and apply field-based criteria for rating or ranking fish hazards at small agricultural diversions. Results of this project will allow prioritization of small diversions on the middle and lower Sacramento River for potential screening or other fish protection treatment.

2. Justification

a. Conceptual Model

Although comprehensive empirical data and information are presently lacking to reasonably quantify fish losses and the benefits derived from screening small agricultural diversions, there are a wide variety of factors (Table 1) that can be qualitatively described in terms of how those factors can influence the loss of fish at diversions and how alleviating or incorporating these factors into fish screening programs could help assess the benefits. CDFG has pointed out that "the magnitude of fish losses at any given diversion depends on a complicated set of relationships which include the size of the fish, the timing of their migration, and the volume and velocity of the diversion in relation to the flow continuing past the diversion." (CDFG 1990). A particular factor that may have an overriding influence at one diversion site could have a negligible influence at another diversion site (Vogel 1995). In examining the topic of main-stem rearing habitat and the downstream migration of young salmon and associated issues with diversions, there are numerous factors that should be considered in evaluating potential benefits of fish screening programs. The following factors are those that will be evaluated and quantified in this project. We propose to focus on these factors because of their relevance in developing criteria to prioritize unscreened diversions for future fish protection.

Magnitude of Water Withdrawal. Hallock and Van Woert (1959) believed that the percentage of river flow diverted could be of equal significance with the time when water is diverted in

determining salmon losses during the migration period. Hallock (1987) suggested that one technique to estimate the total losses of downstream migrant salmon into unscreened diversions would be based on the percent of the river flow diverted multiplied by the number of salmonids migrating downstream during the diversion period. This hypothesis assumes that fish are entrained in direct proportion to flow diverted; it will be evaluated in this project, in part, by comparing rates of entrainment among varying sizes of diversions.

Localized Configuration of the Diversion Intake. Size and type of pump, depth of intake, distance between intake and the river bank, angle at which the intake pipe enters the water, velocity of flow past the intake, size and type of intake screen, and position of the intakes were considered as important factors by Hallock and Van Woert (1959) that would influence fish losses to diversions. Researchers have provided useful information demonstrating that juvenile salmon can exhibit markedly different behavior in the vicinity of trashracks and among variations in trashrack spacing (Reading 1982, Hanson and Li 1983, Kano 1987). Physical features of small unscreened diversions in the riverine environment will be quantified and evaluated in this project.

Orientation of the Diversion Intake in the River Channel. Figure 2 provides some example orientations of water diversion intakes in a riverine channel. Each of these locations may make the intakes a greater hazard (or alternatively, a lesser hazard) to young salmon depending on site-specific considerations (Vogel 1995). In most instances, there has been insufficient research to determine specific "susceptibility hazard factors" to salmon for these various locations. However, it is widely recognized that fish diverted into an intake channel with no bypass flow back to the river would be unlikely to survive. Downstream migrants following flow under these latter conditions would have to swim back upstream out of the intake channel to escape hazards (e.g., predators, entrainment). Upstream migration of downstream migrant fish would be an uncharacteristic behavior response (Vogel 1995). Unscreened small diversions will be selected for this evaluation to encompass the range of sites most commonly utilized on the middle and lower Sacramento River.

Proximity of Diversion to Salmon Rearing Habitat and Migration Corridors. The long-term biological assessment for the CVP suggested that the greatest losses of young salmon to unscreened diversions may primarily occur in the upper river reaches since during the irrigation season water temperatures in the lower river reaches may cause undesirable (extreme) rearing conditions for salmonids. The presence of young salmon in the lower river reaches may only occur during the later portion of the irrigation season (USBR 1992), presumably because water temperatures become more satisfactory for salmon rearing because of cooler seasonal conditions. The presence of a water diversion in the vicinity of principal salmon rearing habitat could result in significant losses of fish because of their longer period of exposure to the diversion site. The magnitude of losses would depend on the "zone of influence" of the diversion in relation to the specific locality of the rearing habitat and the proximity of the diversion intake to the primary migration corridors. (Vogel 1995) This evaluation will also stratify sites by longitudinal location in

the river to determine potential attendant effects of distance from principal salmonid rearing habitats. We also propose to select sites off the main river channel in side channels (e.g., oxbows) that may provide data outside primary fish outmigration corridors.

b. Research Project Hypothesis and Adaptive Management Implications

This proposal describes ***targeted research*** to augment and complement existing pilot demonstration fish screening projects and the implementation-level Sacramento River Small Diversion Fish Screen Program. Uncertainty remains as to the impact of small diversions and the benefits to be derived from fish screening (CALFED 2001 Draft Stage 1 Implementation Plan). Further, it is not yet fully known what level of benefit-to-cost may be expected from screening diversions of different sizes. Incremental improvements to fish survival resulting from screening projects have not yet been fully evaluated. Because there exists the potential to create hazards for fish by placing any structure in the river (e.g., predator habitat, physical injury), alternatives to fish screens for fish protection at small diversions may be worthwhile to consider. Through a systematic process we propose to evaluate the factors outlined in our conceptual model for small diversions on the middle and lower Sacramento River in order to identify criteria that can be used to determine the severity of potential for impact, to determine necessary fish protection and to prioritize diversions to receive fish protection. This program will stratify diversion types based on site-specific characteristics and extrapolate results to other similar types of diversions in the middle and lower Sacramento River. The research for this project is essential to obtain data on unscreened small diversions to facilitate and prioritize future restoration actions for Sacramento River basin anadromous salmonids.

The following is the primary hypothesis addressed in this project:

> **H_0: Unscreened water diversions entrain juvenile salmonids in direct proportion to flow diverted.**

This hypothesis will be tested by quantifying, monitoring, and comparing specific characteristics associated with different types of small unscreened diversions. Fish sampling at each selected small unscreened diversion outfall will be performed to determine total fish entrainment in relation to flow diverted. The total flow diverted will be directly measured or calculated based on physical features of the diversion (e.g., pump size, pipe diameter, lift, etc.). Fish will be sampled with fyke nets positioned at each diversion outfall. Although the numbers of fish passing each diversion site in the river will remain unknown, fish entrainment at each diversion will be compared to other diversions sampled during the same time intervals to determine potential differences or similarities in flow diverted/entrainment rates. These data will be compared among varies sizes of small diversions to ascertain potential relationships. For example, for this hypothesis to be accepted, a 10 cfs diversion would be expected to entrain twice as many fish as a 5 cfs diversion. Although fish mark/recapture experiments are not part of this evaluation, we anticipate collecting data concurrent with the mass releases of marked juvenile salmon from Coleman National Fish

Hatchery upstream of the unscreened diversion sites to obtain additional data on potential flow/entrainment relationships.

If this hypothesis is rejected, then our alternative hypothesis would be accepted:

> **H_1: Unscreened water diversions do not entrain juvenile salmonids in direct proportion to flow diverted.**

If the alternative hypothesis is accepted, correlations between fish entrainment and physical features of each small diversion will be evaluated to determine which factor or suite of factors corresponds to the highest and lowest rates of fish entrainment. It would be assumed that there are site-specific characteristics associated with each unscreened diversion that will provide criteria to prioritize screening small diversions. Statistical analyses will be used to compare variables such as entrainment rates among similar sites and between dissimilar sites. To the extent that results can be expressed as comparisons of means between groups, ANOVA and t-tests will be used to determine any significant differences. Correlation analyses will be performed to determine potential significant relationships between variables measured at each diversion and fish entrainment rates. This evaluation may also determine that there are "thresholds" where entrainment rates change markedly.

3. Approach

Selected small agricultural diversions along the mainstem middle and lower Sacramento River between approximately the Stony Creek confluence to the American River confluence (Figure 1) will be evaluated. A number of factors and issues associated with diversions and implicated with creating hazards for fish will be considered in this evaluation. Each of the following tasks will be performed to evaluate selected site-specific characteristics that can influence each diversion's effects on fish. A criteria rating/ranking/scoring list will be developed based on results of this evaluation. Unscreened diversions will be selected to allow for extrapolation of results to other similar unscreened diversions thereby providing greater benefits than just those selected in this evaluation.

Task 1: Inventory and Categorize types of diversions.

Results of this project will be used to categorize specific types of unscreened small diversions representative of the majority of unscreened diversions in the middle and lower Sacramento River system. Therefore, an initial field survey of the entire middle to lower Sacramento River from Stony Creek to the American River will be performed to locate and categorize types of diversions. Any field surveys previously performed by CDFG or other agencies will be incorporated into this initial task. Examples of small diversion features documented in this task include: pipe size, number of pipes, configuration of intake (e.g., slant, vertical) and supporting structures, where

intakes are located in the river channel (e.g., inside or outside river bend, oxbow, etc.) (see Figure 2), longitudinal location by river mile (to the nearest 0.1 mile), and fish habitat types at each location. This information will be used to initially stratify the types of diversions that will be assessed in further detail for Task 3.

Task 2: Develop an outreach program with landowners to participate in the project

The Family Water Alliance will serve as liaison with landowners to gain access to diversions for evaluations. Family Water Alliance's proven track record as a liaison between landowners and state and federal agencies has been the basis for the success of the screening program. This coordination and communication with the landowner will continue throughout this program, thus guaranteeing its successful implementation. Family Water Alliance a non-profit organization deeply rooted in the rural community has been working in conjunction with USDA Natural Resources Conservation Service to assist landowners with the screening of their agricultural diversions since 1997. Through this program Family Water Alliance has established itself as an organization that is not only sensitive to resource issues, but has the ability to represent farmers interests to state and federal agencies. This ability to communicate concerns and issues, which result in proactive measures, has developed into a unique relationship within the community that is founded in trust, fairness, and in the ability to get the job done. This program will use the established foundation of trust and mutual-respect for private property rights, water rights, and rural issues to develop the outreach efforts for this sampling program. Family Water Alliance using their unique position in the community will work to identify landowners and acquire commitment to the program. Of key importance to continue landowner participation in this type of a program, is to guarantee regulatory assurances to landowners. The success of the screening program has been based on the fact that Family Water Alliance has been with the farmer from inception of the project to the installation of the screen, and through the monitoring phase. Family Water Alliance will continue to use this type of proven approach in this proposal.

Task 3 Measure site-specific physical features of small diversions by type of diversion

An initial selection of small diversions will be made to stratify diversions by similar characteristics. The flow in each of those diversions will be measured or computed to determine volume of water diverted. Based on flow diverted and physical characteristics from Task 1, a final selection of approximately 25 diversions will be made to stratify according to similar diversion features. This stratification will include prioritization by magnitude of flow (e.g., 1-5 cfs, >5-10 cfs, 10-15 cfs or other appropriate delineation). The specific stratification by flow will not be known until initial flow measurements or computations are made for representative sites. Depending on the numbers of small diversion with similar characteristics, additional stratification attributes may include characteristics previously discussed such as: diversion site in relation to the river channel (see Figure 2), fish habitat characteristics at the diversion site, flow and velocity characteristics at the diversion intake (e.g., bypass flows, reverse flows, back eddies, etc.). The sampling matrix will

ensure that representative sites are selected throughout the longitudinal river reach.

After the diversion types have been stratified based on similar features, detailed measurements of physical characteristics at each site will be made during each of the three months when fish entrainment sampling occurs (i.e., April-June, 2003 and April-June 2004). Total flow passing the diversion sites will be approximated based on the nearest USGS or DWR stream gauging station adjusted for any significant accretions or depletions between the stream gauge and diversion site. Those data may be supplemented with Acoustic Doppler Current Profiler (ADCP) meter cross-sectional profiling to acquire additional flow data in reaches where DWR or USGS gauge data may be sparse or lacking. Water temperatures will be measured hourly at each site using thermographs to obtain thermal histories to correlate with fish entrainment data and will provide valuable insight for the potential presence or absence of anadromous salmonids at the point of diversion. For example, changes in the river temperatures may occur longitudinally in the river, downstream of accretions, and seasonally. Additionally, we may find that water temperatures at some sites further removed from mainstem flowing water (e.g., inside oxbows) may be significantly warmer precluding the presence of anadromous salmonids. The flow structure at each diversion intake will be mapped with an ADCP to quantify site-specific water velocity distributions at the diversion.

Task 4 Quantify fish entrainment for each diversion

A series or network of sampling stations at irrigation intake outfalls will be established among all sites selected in Task 3. Fish sampling at each diversion outfall will be performed for approximately 96 hours each week during April-June in 2003 and April-June 2004. Fish sampling will be performed April through June when fish numbers are expected to be the highest (Vogel and Marine 1991), thereby increasing sample sizes and reliability in final results. Based on our prior experience, the numbers of anadromous salmonids present in the middle to lower Sacramento River during the summer is extremely low and therefore this period was not included in the sampling program. The timing of sampling in the spring will be adjusted to ensure that sampling occurs when the majority of fish from Coleman National Fish Hatchery are expected to pass the diversion sites to maximize fish sample sizes at each diversion. Fish sampling will be performed with fyke nets and flow filtered by each net will be measured with General Oceanics meters. Fish sampling will be performed on the same days at each site for consistency between sites. Fyke nets will be checked once daily. Fish will be identified to species and total numbers of each species sampled each day will be recorded. Fork length of anadromous salmonids sampled will be recorded to the nearest millimeter.

Task 5 Project Management

The Project Manager (Principal Investigator) will manage the project cost and schedule, coordinate and communicate with agency staff, the subcontractor Family Water Alliance and

provide fiscal and programmatic reports to the CALFED Grant Manager. The Project Manager will prepare quarterly reports summarizing degree of completion, activities during the reporting period, costs incurred, and project milestones.

4. Feasibility

All aspects of the field measurements for this project can be performed using standardized fish sampling and field survey techniques. The project team has the expertise and support services necessary (see Qualifications) to perform the proposed tasks within the proposed time line. Although the project team possesses the necessary scientific collector's permits, it is assumed that authorization will be required from NMFS, CDFG, and USFWS to sample fish entrained into unscreened diversions. Regulatory assurances to participating landowners will be necessary to ensure diverters would not be subject to penalties based on data collected during this project. Because specific sites for evaluating small unscreened diversions are not known at this time, an outreach program through the Family Water Alliance will be established at the beginning of the project to seek landowners willing to provide access to their diversion facilities. Family Water Alliance will not only be involved at the onset to identify landowners, but will be available to act on the landowners behalf as the two-year project unfolds.

5. Performance Measures

Performance measures for this project will be in the form of written technical documentation of the research project describing experimental design, study protocols, a quality assurance program plan, data collected, analyses performed, and final results and recommendations. A written technical report will be peer reviewed by CALFED staff. Additionally, a technical presentation to CALFED will be provided, if requested.

6. Data Handling and Storage

All data collected as part of this monitoring program will be measured using standard English units unless the contemporary scientific conventions require *Systema Internationale* (SI) units. Measurements will be made to the lowest practicable precision as appropriate for the subject of the measurement. GPS measurements will be made using Universal Transverse Mercator units using a NAD27 datum. Water velocity data will be in feet per second and flow data will be in cubic feet per second (cfs). All measurements will be checked for aberrant values before leaving measurement sites. Conversions of SI units to English units for computations will be made where necessary and clearly documented in example calculations. All calculated values will be computed twice to insure accuracy.

Data sheets will be examined by investigators in the field prior to leaving a site to ensure that all data are recorded and measurements look reasonable. Any deficiencies will be addressed at the

site. All data will be subjected to double data entry verification. Investigators' names (all employees of Natural Resource Scientists, Inc.) will be recorded on each field data sheet. All raw data sheets will be photocopied with one set kept on file with Natural Resource Scientists, Inc. for archival purposes. Graphical data plots will be used to examine data sets for aberrant data and outliers and corrective actions will be taken. Computed values will be calculated twice to insure accuracy. Time series data will be maintained in a database, while physical data will be maintained in tables. All data will be available on electronic media both during the project, as data become available, as well as upon project completion. All figures, tables, and data sets generated during the study will be reviewed by the Principal Investigator prior to submission to CALFED. Computer files will be backed up weekly and backup tapes will kept in a fire proof safe. Copies of all final computer data files and hard copies of data submissions will be provided to CALFED if requested.

7. Expected Products/Outcomes

Quarterly fiscal and programmatic reports will be prepared and provided according to CALFED guidelines. The Project Manager will submit a draft and final CALFED-approved Monitoring Plan/QAPP. At the end of the project, a technical, peer-reviewed draft and final report will be completed describing all work performed and study results, including methodologies, data acquired during the project, and the analyses of results. Reports and data will be submitted in electronic format for entry into the CALFED database. In addition to a written report, one formal technical presentation on the project may be given to CALFED, if requested.

8. Work Schedule

A draft and final CALFED-approved Monitoring Plan/QAPP will be submitted in October 2002. Preliminary field reconnaissance and preparations (Task 1) would be performed during March 2003. Field portions of the study would be conducted during April, May, and June of 2003 and April, May, and June of 2004 (Tasks 3 and 4). Task2 (Landowner Outreach) and Task 5 (Project Management) would occur from October 2002 through September 2004. None of the tasks are separable. A draft report will be prepared describing each task and submitted for peer review by CALFED by September 2004. A final report, incorporating reviewer comments, will be completed and submitted within a month after receipt of comments.

B. Applicability to CALFED's ERP And Science Program Goals And Implementation Plan And CVPIA Priorities

1. ERP, Science Program and CVPIA Priorities

Our proposed targeted research/evaluation project directly addresses *Restoration Priorities and Actions for the Sacramento Region: SR-6, Continue major fish screen projects and conduct*

studies to improve knowledge of implications of fish screens for fish populations in the Draft Stage 1 Implementation Plan. This priority specifically identifies the need for investigations that focus on development of selection criteria for screening diversions. Our project will subject a wide variety of small irrigation diversions to an analysis of factors associated with diversion hazards for anadromous salmonids and other at-risk species. Similarly, this Draft Stage 1 PSP priority identifies the need to evaluate alternatives to fish screens. The tasks outlined by our proposal will serve to reduce uncertainties currently associated with fish protection requirements for small diversions, addressing CALFED Science Program priorities, and guide identification of fish protection measures that include screens and other appropriate measures. Our proposal will support ERP Strategic Goal #1 to achieve recovery of at-risk species (CALFED 1999a, 1999b). Screening irrigation diversions along the Sacramento River is a high priority action for the CVPIA. Stabilizing and improving population status of all runs of anadromous salmonids, especially the federally ESA-listed winter and spring runs of chinook salmon and steelhead (NMFS 1998, 2000), is a principal objective for fish screening programs on the Sacramento River.

2. Relationship to Other Ecosystem Restoration Projects

A number of agencies (many are CALFED participating agencies) have responsibility and authority dealing with fish protection at diversions and fish screening issues, including CDFG, USFWS, CDWR, USBR, State Water Resources Control Board, NRCS, NMFS, and the US Army Corps of Engineers. Many of these agencies currently participate in several ongoing efforts to reduce the impacts of unscreened diversions in Sacramento Basin streams, the Bay-Delta, and throughout the other Central Valley river basins, including CDFG's Unscreened Diversion Program, the CVPIA's Anadromous Fish Screen Program, NRCS's Sacramento River Small Diversion Fish Screen Program. Our proposed project will provide assessment information and guidance highly applicable to these ongoing programs for prioritizing small agricultural diversions that require fish protection.

Our proposed project is closely linked to other ecosystem restoration efforts along the middle and lower Sacramento River that are focused on improving and restoring aquatic and riparian habitats such as those promoted by the California Senate Bill 1086 *Upper Sacramento River Fisheries and Riparian Habitat Management Plan* and being coordinated and implemented through the Sacramento River Conservation Area program. Identifying and providing efficient fish protection and screening of small diversions, especially for those with the greatest fish entrainment potential, will further ensure that agricultural water diversion does not impair improvements to fishery production resulting from habitat restoration.

3. Request for Next-Phase Funding

Not applicable.

4. Previous Recipient of CALFED Program or CVPIA funding

Natural Resource Scientists, Inc. has received CALFED and CVPIA funding for Central Valley projects. In 1995, a final contract peer-reviewed report entitled: "*Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne Rivers*" was completed by NRS, Inc. under a subcontract with CVPIA AFRP funding (prime contract number is unknown). In May 2000, a contract peer-reviewed report entitled: "*Juvenile Chinook Salmon Radio-Telemetry Study in the Northern Sacramento - San Joaquin Delta, January - February 2000*" was completed for the CVPIA AFRP (open contract, order no. 101810M102). In August 2001, a draft CVPIA AFRP contract report entitled: "*Juvenile Chinook Salmon Radio-Telemetry Study in the Southern Sacramento - San Joaquin Delta, December 2000 - January 2001*" was submitted to the IEP for peer review (Contract No. 101811D027). Results of a CALFED field study of juvenile salmon at the Delta Cross Channel (DCC) during November 2000 were presented at the IEP 2001 Asilomar conference and a written report is in progress (CALFED DCC study contract no. unknown). An expanded version of the DCC studies for 2001 was recently approved by the CALFED Science Panel and funding was approved in September 2001; no funds have been expended to date. Three research projects, "*Juvenile Salmon Migratory Behavior Study in the North, Central, and South Delta*" was recently approved by CALFED (CALFED Project No. ERP-01-N48) and a contract was executed with the National Fish and Wildlife Foundation in September 2001; no funds have been expended to date. A project on the initial phase of a "*Merced River Water Temperature Management Feasibility Study*" (2001-K203) was recently approved by CALFED and a USFWS CVPIA contract is being developed with the USFWS; no funds have been expended to date. NRS, Inc. is working on the AFRP project "*Merced River Wing-Dam Monitoring, 2000-2002"* on behalf of Merced ID (FWS Agreement #113320J027).

Family Water Alliance is a subcontractor with Natural Resources Conservation Service CALFED work but do not have direct CALFED contracts. The NRCS CALFED contracts are $900,000 Fish Screens, CALFED# 1425-99-AA-20-1770 and $312,000 CALFED 2000-R01. FWA is currently writing agreement documents for a CALFED grant for phase 2 of the fish screen program, but do not have an executed CALFED contract at this time.

5. System-Wide Ecosystem Benefits

Improvements in salmonid production in upstream river reaches and tributaries resulting from implementation of restoration actions, such as Shasta Dam temperature control, Clear Creek, Battle Creek, and Butte Creek restoration projects, will ultimately benefit from our proposal through improved and ensured fish protection for rearing and emigrating juvenile salmonids passing mid- and lower river small irrigation diversions. Improved fish survival in the middle and lower reaches of the Sacramento River will propagate downstream to the Delta where habitat restoration and fish protection actions there can further benefit fish survival and ultimate population recoveries.

C. Qualifications

David A. Vogel, Project Manager/Principal Investigator
Natural Resource Scientists, Inc. Senior Scientist
M.S., 1979, Natural Resources (Fisheries), University of Michigan
B.S., 1974, Biology, Bowling Green State University

Mr. Vogel specializes in aquatic resource assessments and resolution of fishery resource issues associated with land and water development. His 25 years of work experience in fisheries has included large-scale assessments in river systems, lakes and reservoirs, and estuaries. Most of his experience has been associated with restoration of western United States fishery resources. Mr. Vogel has worked on projects to define interrelationships of salmon resources and water project operations. He was the Task Manager for the Biological Assessment of the 1992 operations of the Central Valley Project (CVP) and was the principal biologist in charge of developing the long-term Biological Assessment for the CVP. He has designed and performed dozens of anadromous salmonid fish sampling programs, many of those including sampling fish at water diversion facilities. Mr. Vogel has been working on Central Valley fishery resource research and management projects and interrelationships with water project operations for 20 years.

Keith R. Marine, Aquatic Ecologist
Natural Resource Scientists, Inc., Aquatic Ecologist
M.S., 1997, Ecology, University of California, Davis
B.S., 1983, Wildlife and Fisheries Biology, University of California, Davis

Mr. Marine will serve as the Aquatic Ecologist for this project because of his expertise in ecological requirements and behavior of native California fishes. Mr. Marine specializes in the ecological sciences with emphasis on fisheries science, aquatic and marine biology, and physiological ecology. He has extensive experience in ecological and biological assessment and conducting research directed at resolving natural resource management problems. Mr. Marine has designed and conducted ecosystem-level investigations on fish migration and behavior associated with operation of large Central Valley Project facilities, including fish responses at fish passage and screening facilities. His expertise includes a comprehensive research background in physiological ecology of California's native fishes, including Pacific anadromous salmonids. He has participated in the design and evaluation of the biological performance of fish screens, including entrainment, physical injury, predation, and physiological responses of juvenile salmonids to fish passage systems. Mr. Marine has performed evaluations of fish populations, fish habitat requirements, stream flow assessments and stream temperature modeling in support of fishery conservation and restoration programs.

Russell L. Liebig, Fishery Biologist
Natural Resource Scientists, Inc., Fishery Biologist

B.S., 1998, Wildlife, Fisheries, and Conservation Biology, University of California, Davis

Mr. Liebig is employed by Natural Resource Scientists, Inc. as a Fishery Biologist working on multiple anadromous fishery resource monitoring projects. These intensive field projects included monitoring of juvenile and adult salmon and steelhead migration on the Mokelumne River, juvenile salmonid downstream migration on Merced River, sonic and radio-tracking of salmon in the Delta, and fish experiments at the Glenn-Colusa Irrigation District on the Sacramento River. These projects required tagging of salmonids using several types of fish marking techniques. His duties also included fish trap calibration and maintenance. Mr. Liebig is very knowledgeable and experienced in the methods and equipment used to sample fish.

Susan A. Sutton, Program Manager, Sacramento River Fish Screen Program
Family Water Alliance, President
M.S., 1989, Counseling and P.P.S. Credential, University of LaVerne
B.A., 1973, Food and Nutrition, California State University of San Francisco

Ms. Sutton specializes in all aspects of management in regards to the fish screen program and Family Water Alliance. Management duties have included grant writing, permit application, outreach and education, publicity, networking, and overall communications. Management has also included the development of strategies, goals, and objectives in regard to the fish screen program and the corporation. In addition, to these responsibilities, Ms. Sutton has initiated and facilitated meetings between adversaries such as the Fish, Farm, and Forest Communities Project and was instrumental in initiating the Spring-Run Work Group. Over the past seven years, Ms. Sutton has raised over $3,700,000 towards fishery restoration efforts.

D. Cost

1. Budget

Total budget for this project is given in the 2002 PSP web forms.

2. Cost-Sharing

Because specific diversion sites will not be known until after the project is initiated, we do not know which landowners, if any, may cost share in the project.

E. Local Involvement

Family Water Alliance has been involved in the Sacramento River Small Diversion Fish Screen Program since 1997. Partners in this program include landowners and farmers, Family Water Alliance, USDA Natural Resource Conservation Service, Colusa County Resource Conservation

District, California Department of Fish and Game, CALFED, National Marine Fisheries Service, NOAA Fisheries Community-based Restoration Program, National Fish and Wildlife Foundation, Pacific Grassroots Salmon Initiative, U.S. Bureau of Reclamation, Fish America Foundation, Chevron Company, and Berkeley-Turner's Outdoorsman Tagged Catfish Extravaganza.

The Family Water Alliance will serve as liaison with landowners to gain access to diversions for evaluations. Family Water Alliance's proven track record as a liaison between landowners and state and federal agencies has been the basis for the success of the screening program. This coordination and communication with the landowner will continue throughout this program, thus guaranteeing its successful implementation.

F. Compliance with Standard Terms And Conditions

Natural Resource Scientists, Inc. will comply with the standard State and Federal contract terms described in Attachments D and E of the CALFED 2002 Proposal Solicitation Package.

G. Literature Cited

CALFED Bay-Delta Program. 1999a. Ecosystem Restoration Program Plan, Strategic Plan for Ecosystem Restoration. Draft Programmatic EIS/EIR Technical Appendix. June 1999.

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Vogel, D.A. 1995. Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne Rivers. Contract report for CVPIA. Vogel Environmental Services. January 1995. 36 pp.

Vogel, D.A. and K.R. Marine. 1991. Guide to Upper Sacramento River chinook salmon life history. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. 55 pp. with appendices.

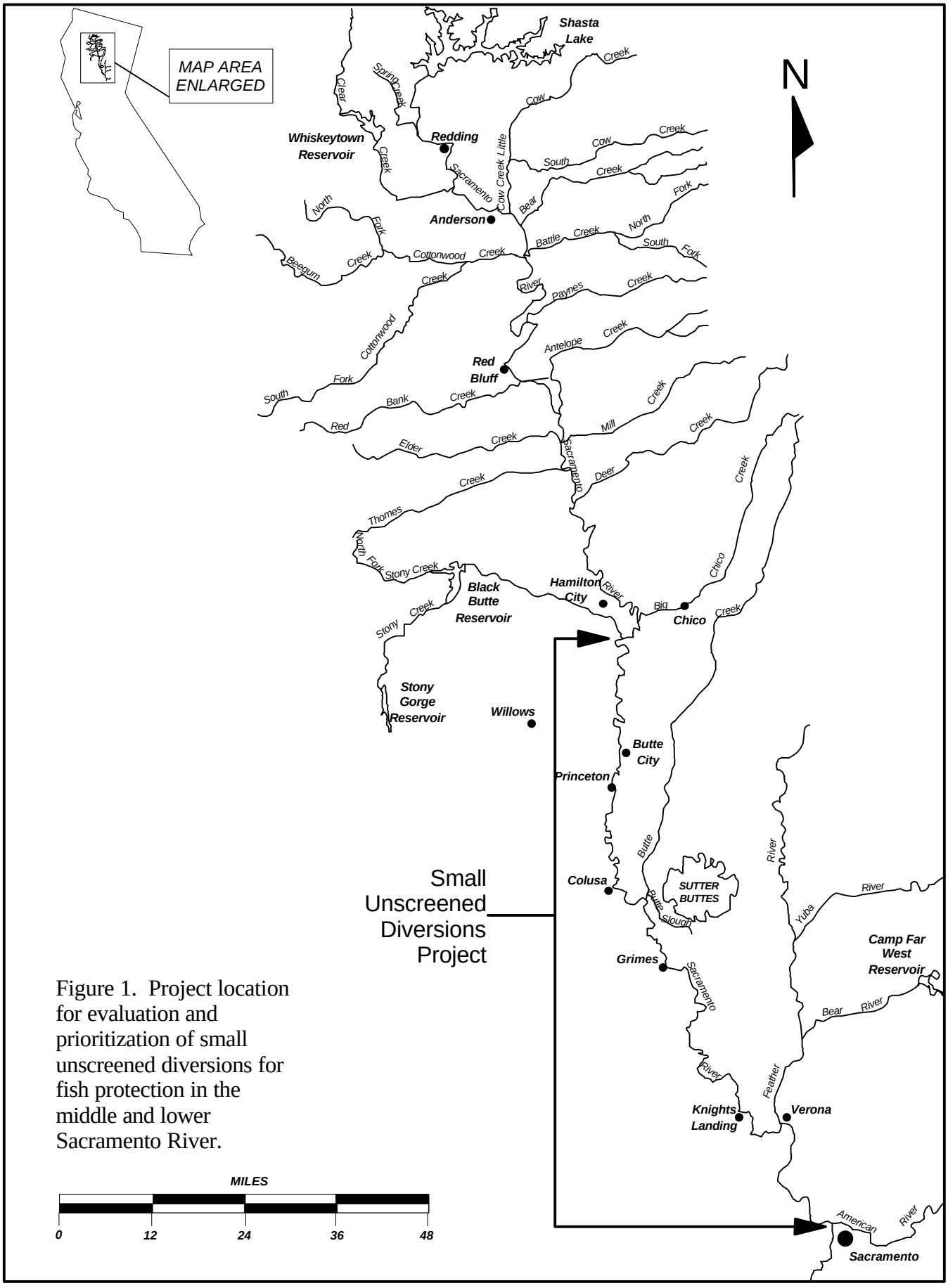

Figure 1. Project location for evaluation and prioritization of small unscreened diversions for fish protection in the middle and lower Sacramento River.

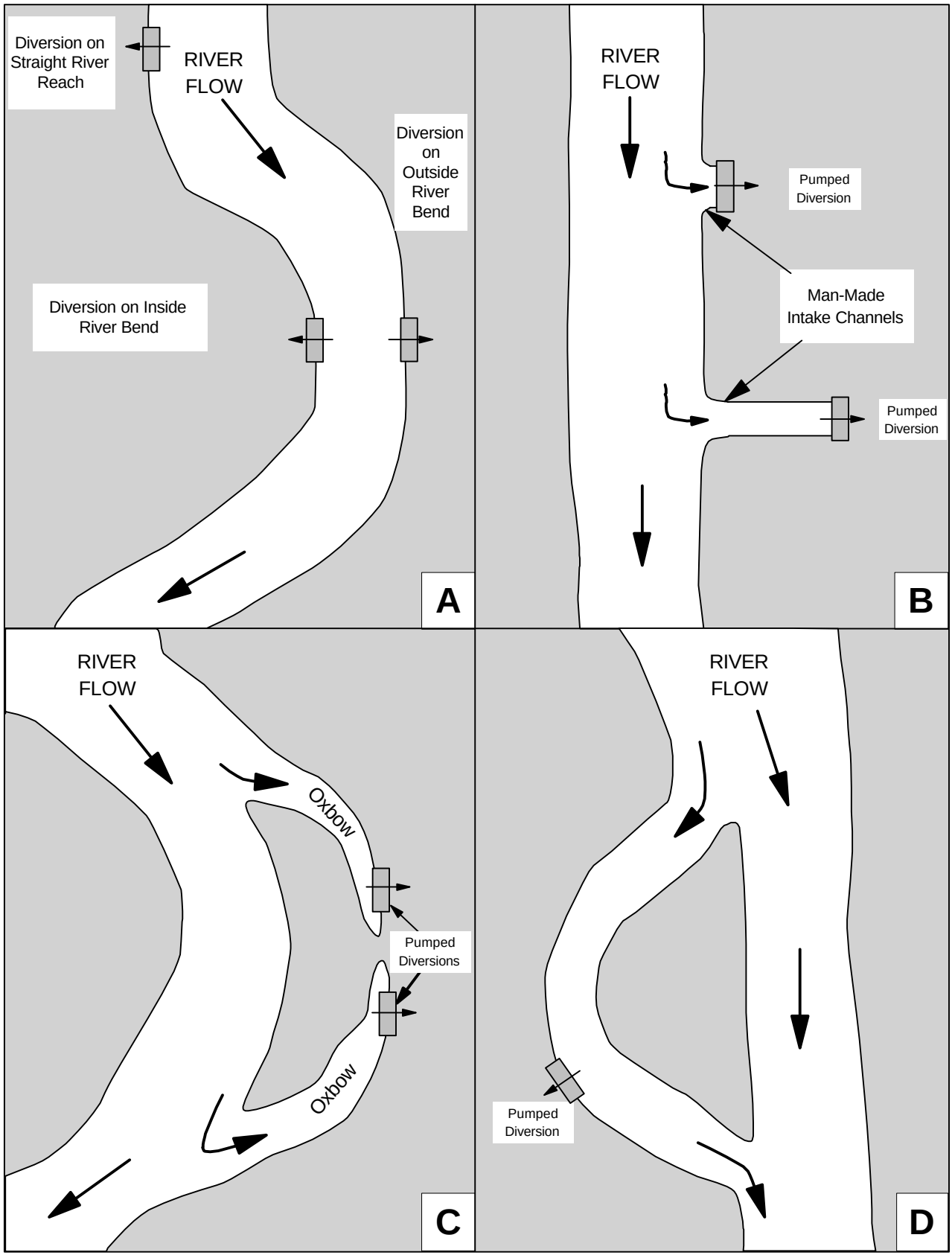

Figure 2. Example variations in locations of riverine diversions. Types B, C, and D can also vary depending on locations on inside bends, outside bends, or straight river reaches (from Vogel 1995).

Table 1. A summary of the principal factors affecting fish losses in unscreened diversions (from Vogel 1995).

- Magnitude of water withdrawal
- Salmon run (e.g., fall, late-fall, winter, spring)
- Seasonal timing of the water diversion
- Proximity of the diversion to rearing habitat
- Geographic location of the water diversion in the river relative to the proportion of juvenile salmon which would ultimately migrate past the diversion
- Hydrologic conditions preceding the principal downstream migration (e.g., wet or dry water year type)
- Specific life phase of the downstream migrants passing the diversion (e.g., fry versus smolt)
- Physical configuration of the diversion intake and associated facilities
- Location of the diversion intake in the water column
- Concentration of the downstream migrants at various location in the water column and across the river channel
- Diel changes in fish distribution and behavior
- Diel changes in water diversion rate
- Water velocity near the diversion intake
- Water temperature in the vicinity of the diversion intake
- Location of the diversion intake in the river channel (e.g., oxbow, inside or outside bend, set back or on the river, etc.
- Absence or presence and concentration of predatory fish at the diversion site