TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

Project Information

1. **Proposal Title:**

   TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

2. **Proposal applicants:**

   NIALL McCARTEN, Environmental Science Associates
   JOHN CALLOWAY, UNIVERSITY OF SAN FRANCISCO
   BERNIE BAUER, UNIVERSITY OF SOUTHERN CALIFORNIA
   ERWIN VAN NIEUWENHUYSE, U.S. BUREAU OF RECLAMATION
   JOHN De GEORGE, RESOURCE MANAGEMENT ASSOCIATES

3. **Corresponding Contact Person:**

   NIALL McCARTEN
   ENVIRONMENTAL SCIENCE ASSOCIATES
   700 UNIVERSITY AVENUE, SUITE 130 SACRAMENTO, CA 95825
   916 564-4500
   nmccarten@esassoc.com

4. **Project Keywords:**

   Geochemistry
   Modeling
   Wetlands, Tidal

5. **Type of project:**

   Implementation_Pilot

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

   No

7. **Topic Area**:

   Shallow Water, Tidal and Marsh Habitat

8. **Type of applicant:**

   Private for profit

9. **Location - GIS coordinates:**

Latitude:	38.184
Longitude:	-122.061
Datum:	NAD83

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

THE SUISUN MARSH IS LOCATED NORTH OF GRIZZLEY BAY IN THE SUISUN BAY PORTION OF THE NORTHERN BAY REGION. IT IS BORDERED ON THE WEST BY HIGHWAY 680, ON THE NORTH BY HIGHWAY 12, AND ON THE EAST BY MONTEZUMA SLOUGH.

10. **Location - Ecozone:**

    2.1 Suisun Bay & Marsh

11. **Location - County:**

    Solano

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    7th

15. **Location:**

    California State Senate District Number: 4

    California Assembly District Number: 8

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

    2 years

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:	$1,791,360

b) Do you have cost share partners <u>already identified</u>?

No

c) Do you have <u>potential</u> 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?

No

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)

STEVEN CULBERTSON	**CALIFORNIA DEPARTMENT OF WATER RESOURCES**	**916/227-2516**

PETER BAYE	**U.S. FISH AND WILDLIFE SERVICE**	**707/562-3003**	**peter_baye@fws.gov**

ELISKA RAJMANKOVA	**UNIVERSITY OF CALIFORNIA, DAVIS**	**530/752-4326**	**erajmankova@ucdavis.edu**
BRENDA GREWELL	**UNIVERSITY OF CALIFORNIA, DAVIS**	**530/752-4326**	**bgrewell@ucdavis.edu**

21. **Comments:**

Environmental Compliance Checklist

<u>TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH</u>

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 PROJECT DOES NOT MEET THE DEFINITION OF "PROJECT" UNDER CEQA OR NEPA.

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

   <u>CEQA Lead Agency:</u>
   <u>NEPA Lead Agency (or co-lead:)</u>
   <u>NEPA Co-Lead Agency (if applicable):</u>

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: CA DEPARTMENT OF WATER RESOURCES Obtained

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

Land Use Checklist

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

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 AND RESTORATION PROJECT ONLY.

4. **Comments.**

Conflict of Interest Checklist

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

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):

NIALL McCARTEN, Environmental Science Associates
JOHN CALLOWAY, UNIVERSITY OF SAN FRANCISCO
BERNIE BAUER, UNIVERSITY OF SOUTHERN CALIFORNIA
ERWIN VAN NIEUWENHUYSE, U.S. BUREAU OF RECLAMATION
JOHN De GEORGE, RESOURCE MANAGEMENT ASSOCIATES

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

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

BERNARD BAUER	UNIVERSITY OF SOUTHERN CALIFORNIA
JOHN De GEORGE	RESOURCE MANAGEMENT ASSOCIATES
JOHN CALLAWAY	UNIVERSITY OF SAN FRANCISCO

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

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

THOMAS TREXLER ENVIRONMENTAL SCIENCE ASSOCIATES

MICHAEL STEVENSON ENVIRONMENTAL SCIENCE ASSOCIATES

ERICH FISCHER ENVIRONMENTAL SCIENCE ASSOCIATES

MATTHEW ZIDAR ENVIRONMENTAL SCIENCE ASSOCIATES

Comments:

Budget Summary

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

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	BIOGEOCHEMISTRY	2,024	149,200		2,500	1,500	9,420		83,200	245820.0		245820.00
2	HYDROLOGY AND SEDIMENTS	1,488	112,600		3,000	2,000	90,410		14,100	222110.0		222110.00
3	MODELING	336	34,400		500	1,600	116,650		5,300	158450.0		158450.00
4	ECOLOGY	3,384	260,200		2,750	1,250	13,850		42,700	320750.0		320750.00
		7232	556400.00	0.00	8750.00	6350.00	230330.00	0.00	145300.00	947130.00	0.00	947130.00

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	BIOGEOCHEMISTRY	2,324	191,00		2,500	1,000	8,590		20,800	51990.0		51990.00
2	HYDROLOGY AND SEDIMENTS	1,244	109,320		1,500	250	52,230		32,500	195800.0		195800.00
3	MODELING	292	31,480		300		224,250		550	256580.0		256580.00
4	ECOLOGY	964	81,100		1,750	250	13,950		22,825	119875.0		119875.00
5	INTEGRATED RESTORATION PLAN	1,880	163,600		2,700	650	47,735		5,300	219985.0		219985.00
		6704	404600.00	0.00	8750.00	2150.00	346755.00	0.00	81975.00	844230.00	0.00	844230.00

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=1791360.00

Comments.

Budget Justification

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

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

M. ZIDAR ESA OFFICE DIRECTOR 376 HOURS N MCCARTEN PROJECT MANAGER, 1800 HOURS C ROGERS ECOLOGIST 608 HOURS T TREXLER WATER CHEMISTRY/HYDROLOGY 2,010 HOURS E FISHCER WILDLIFE AND GIS 440 HOURS A GERSTELL WILDLIFE 480 HOURS B PITTMAN INVERTEBRATE ECOLOGIST 1,050 M STEVENSON LIMNOLOGY WATER CHEMISTRY 1,800 HOURS ASSOCIATE 3 STAFF ECOLOGISTS 3,120 ASSOCIATE 2 STAFF SCIENTISTS 1359 HOURS ADMINISTRATION 620 HOURS

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

M. ZIDAR ESA OFFICE DIRECTOR $57,725 N MCCARTEN PROJECT MANAGER, $218,700 C ROGERS ECOLOGIST $63,770 T TREXLER WATER CHEMISTRY/HYDROLOGY $215,300 E FISHCER WILDLIFE AND GIS $80,000 A GERSTELL WILDLIFE $120,000 B PITTMAN INVERTEBRATE ECOLOGIST $160,000 M STEVENSON LIMNOLOGY WATER CHEMISTRY $250,076 ASSOCIATE 3 STAFF ECOLOGISTS $267,000 ASSOCIATE 2 STAFF SCIENTISTS $$172,000 ADMINISTRATION $143,7300

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

NONE.

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

TRAVEL COSTS FOR ESA STAFF WILL INCLUDE TRAVEL FOR FIELD MONITORING AT SUISUN MARSH DURING A 12-15 MONTH PERIOD. IT WILL ALSO INCLUDE TRAVEL TO CONFERENCES AND MEETINGS WITH AGENCY STAFF AND SUBCONSULTANTS. TOTAL TRAVEL COSTS FOR ESA STAFF WILL BE $14,750 TRAVEL EXPENSES FOR CONSULTANTS WILL BE $5,025

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

FIELD SUPPLIES WILL INCLUDE FLAGS, STAKES, MAPPING MATERIALS, 35 MM FILM FOR PHOTODOCUMENTATION, SAMPLING VIALS ETC. TOTAL FOR FIELD SUPPLIES WILL BE $2,250 COMPUTING SUPPLIES- MINOR SOFTWARE UPGRADE FOR CANOCO ($450), GIS COMPUTING TIME $3,700

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.

CONSULTANT AND THEIR BUDGETS PER TASK ARE GIVEN BELOW: BERNARD BAUER, USC- $198,000 JOHN CALLAWAY, USF - $45,525 RESOURCES MANAGEMENT ASSOCIATES- $333,560

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.

M ZIDAR WILL SPEND APPROXIMATELY 45% OF HIS BUDGET TO ENSURE SCHEDULES ARE MET, QUARTERLY REPORTS AND TECHNICAL REPORTS ARE PRODUCED, REVIEWED AND SUBMITTED. N MCCARTEN WILL BE THE TECHNICAL PROJECT MANAGER AND HE WILL SPEND APPROXIMATELY 15% OF HIS TIME AND BUDGET TO ENSURE FIELD AND OTHER STAFF ARE CONDUCTING THE APPROPRIATE STUDIES AND DEVELOPING THE REQUIRED TECHNICAL REPORTS. HE WILL PREPARE THE QUARTERLY REPORTS FOR CALFED. HE WILL BE RESPONSIBLE FOR COORDINATING WITH ESA STAFF AND ALL SUBCONTRACTORS AND ENSURING THAT ALL NECESSARY PERMITS ARE OBTAINED.

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

TOTAL $ 223,000 SOILS ANALYSIS- $32,500 WATER ANALYSIS FROM INDEPENDENT LABS- $52,000 IN-HOUSE WATER ANALYSIS $15,000 EQUIPMENT RENTALS FOR FIELD MONITORING WATER QUALITY AUTOSAMPLERS $48,000 PLANT AND SOIL FIELD EQUIPMENT $ 31,000 DATA LOGGERS WITH PROBES $29,500 PURCHASES PIEZOMETERS- $15,000

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.

NONE

Executive Summary

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

THIS PROJECT WILL IDENTIFY ABIOTIC AND BIOTIC PROCESSES THAT DETERMINE THE STRUCTURE AND FUNCTION OF TIDAL BRACKISH MARSH ASSOCIATED WITH FIRST- AND SECOND-ORDER TIDAL CHANNELS WITHIN THE HIGHER-ORDER CHANNEL SYSTEMS IN SUISUN MARSH. THE PROCESSES DRIVING FORMATION AND PERSISTANCE OF THESE LOWER-ORDER CHANNELS ARE POORLY UNDERSTOOD; HOWEVER, SEVERAL AT-RISK SPECIES, INCLUDING THE CALIFORNIA CLAPPER RAIL AND THE SUISUN MARSH THISTLE, DEPEND ON THESE CHANNELS AS ESSENTIAL HABITAT ELEMENTS. WE HYPOTHESIZE THAT A BETTER UNDERSTANDING OF THE BIOGEOCHEMICAL, HYDROLOGIC AND OTHER PHYSICAL PROCESSES DRIVING LOWER ORDER CHANNELS AND THEIR DEVELOPMENT WILL INCREASE OUR ABILITY TO SUSTAIN AND RESTORE THIS HABITAT TYPE FOR AT-RISK SPECIES. THE OBJECTIVES OF THE STUDY ARE: 1) TO IDENTIFY KEY HYDROLOGICAL PROCESSES OF LOWER-ORDER TIDAL CHANNELS, 2) TO IDENTIFY KEY BIOGEOCHEMICAL PROCESSES THAT MAY BE UNIQUE TO LOWER-ORDER CHANNELS, 3) TO IDENTIFY GEOMORPHOLOGICAL PROCESSES UNIQUE TO LOWER-ORDER CHANNELS AND POTENTIALLY UNIQUE TO SUISUN MARSH DUE TO AGRICULTURAL RUNOFF, 4) TO CORRELATE VEGETATION STRUCTURE AND COMPOSITION WITH THE ABIOTIC FACTORS, AND 5) TO IDENTIFY THE STRUCTURE OF INVERTEBRATE COMMUNITIES IN THE TIDAL CHANNELS AND VERTEBRATE COMMUNITIES WITH THE CHANNELS AND THE ASSOCIATED VEGETATION. SEVERAL STUDY SITES WILL BE CHOSEN FOR DETAILED ANALYSIS. A DETAILED ECOLOGICAL PROCESS AND SPATIAL MODEL WILL BE DEVELOPED BASED ON THE COLLECTED DATA AND NUMERICAL MODELING OF THE HYDROLOGICAL PROCESSES. THIS MODEL AND OTHER COLLECTED DATA WILL BE USED TO DEVELOP A PHASE 1 INTEGRATED RESTORATION DESIGN MODEL FOR CREATING AND LINKING LOWER ORDER TIDAL CHANNELS TO EXISTING HIGHER ORDER TIDAL CHANNELS. A RESTORATION PLAN WILL BE DEVELOPED FOR PILOT/DEMONSTRATION RESTORATION PROJECTS TO BE CARRIED OUT IN PHASE 2. THIS PROJECT WILL ADDRESS THE FOLLOWING CALFED STRATEGIC GOALS: AT-RISK SPECIES, ECOSYSTEM PROCESS, HABITATS, AND WATER AND SEDIMENT QUALITY. IT WILL ALSO SUPPORT BAY REGIONAL PRIORITIES, INCLUDING MARSH RESTORATION IN SUISUN BAY, AND MODELING AND PHYSICAL MEASUREMENT STUDIES TO INCREASE UNDERSTANDING OF PHYSICAL AND BIOTIC PROCESSES, SUCH AS EDAPHIC REQUIREMENTS OF SENSITIVE PLANT SPECIES.

Proposal

Environmental Science Associates

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION OF LOW-ORDER CHANNELS IN SUISUN MARSH

NIALL McCARTEN, Environmental Science Associates
JOHN CALLOWAY, UNIVERSITY OF SAN FRANCISCO
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JOHN De GEORGE, RESOURCE MANAGEMENT ASSOCIATES

TIDAL HYDROLOGY, BIOGEOCHEMISTRY, AND BIOTIC STRUCTURE AND FUNCTION ASSOCIATED WITH LOW-ORDER TIDAL CHANNELS IN SUISUN MARSH

A. Project Description

This project will identify abiotic and biotic processes that determine the structure and function of tidal brackish marsh associated with first- and second-order tidal channels within the higher-order channel systems in Suisun Marsh (Figure 1). Biogeochemical processes, nutrient inputs, outputs and transformation, diel and seasonal tidal flux, seasonal freshwater inputs, agricultural runoff, sedimentation and erosion, and plant, invertebrate, and vertebrate community structure will be measured in the smaller tidal channel systems. An ecological process and spatial model will be developed based on the collected data and numerical modeling of the hydrological processes. This model and other collected data will be used to develop a Phase 1 integrated restoration design model for creating and linking lower order tidal channels to existing higher order tidal channels. A restoration plan will be developed for pilot/demonstration restoration projects to be carried out in Phase 2.

1. Problem

Much of the structure, function and biological diversity in tidal marshes, such as Suisun Marsh, have been eliminated due to human-caused disturbance. Over 90 percent of all tidal wetlands in the Delta and Bay regions were diked, and the tidal wetland functions were subsequently lost. Proposed large-scale restoration projects, such as levee breaches, will restore hydrological processes (i.e. tidal action), and address large-scale elevation issues associated with subsidence and tidal flows through large higher-order channel systems. However, finer scale processes that influence the structure of lower-order tidal channels (Figure 2), and their associated wetland communities, are poorly understood (Callaway 2001). Site-specific studies in Suisun Marsh and studies of brackish marsh ecology have primarily been limited to qualitative observations. The size of tidal channels has been correlated with vegetation composition and structure (Sanderson 1999, Keddy 2000, Callaway 2001), and tidal restoration projects have observed that the interaction of hydrology, biogeochemistry, and substrate factors play a major role in determining the success of a restoration project (Zedler 2001, Callaway 2001).

The localized distribution of CALFED At-risk plant and wildlife species in Suisun Marsh demonstrates that habitat needs for some species are not being met (DWR 1994). Two specific examples of At-risk species that require the smaller tidal channels for their survival are the California clapper rail and Suisun Marsh thistle (*Cirsium hydrophilum* var. *hydrophilum*). The California clapper rail forages on invertebrates in tidal channels and these channels must have the requisite vegetation cover (Albertson, pers. comm.). The Suisun thistle, known from only two populations, grows along small, shallow tidal channels and to a much lesser extent along created mosquito channels (DWR 1994, B. Grewell, pers. comm.). Recovery of these two species will be dependent on our ability to recreate and restore their specific habitat requirements. We hypothesize that a better understanding of the biogeochemical, hydrologic and other physical processes driving lower order channels and their development will increase our ability to sustain and restore this habitat type for At-risk species.

The principal goal of this project will be to develop an integrated restoration model based on a synthesis of hydrological, biogeochemical, and geomorphological processes that affect and interact with vegetation. To reach this goal we will complete five objectives. The objectives are to: 1) identify key hydrological processes of lower-order tidal channels, 2) identify key biogeochemical processes that may be unique to lower-order channels, 3) identify geomorphological processes unique to lower-order channels and potentially unique to Suisun Marsh due to agricultural runoff, 4) correlate vegetation structure and composition with the abiotic factors, and 5) identify the structure of invertebrate communities in the tidal channels and vertebrate communities with the channels and the associated vegetation.

The model will represent Phase I our project. Phase I will also result in development of the integrated restoration model and restoration plan for lower-order tidal channels in Suisun Marsh. Phase II consist of a pilot/demonstration restoration in Suisun Marsh to evaluate our integrated model, and to determine if we can successfully accelerate the restoration of lower-order tidal channels.

2. Justification

Evaluating ecological systems at different spatial (process-level) and temporal scales is important for ecosystem management (Hobbs 1998). The relative contribution of biotic and abiotic processes to habitat and community structure and function depends on the spatial and temporal scale being observed. Human-caused disturbances include removing or limiting tidal inputs, changing the size and shape of channels, importing fill to counter subsidence, introducing non-native invasive species, increasing upland runoff causing higher sedimentation, or introducing water discharge into channels causing higher rates of erosion. The impacts of these human disturbances depend on the scale of the disturbance regime (Pahl-Wostl 1998). These impacts will determine whether a tidal marsh is a net sink or source for nutrients and whether the marsh functions as a transformer of those nutrients (Odum et al. 1984). Also, these factors will contribute to the structure and function of the tidal wetland community. The diversity and quantity of vegetation, invertebrates, and vertebrate species are ultimately affected. Significant differences in the biogeochemistry and its effect on productivity have been observed for tidal marshes between high and low elevation zones. Additionally, the modification of the tidal regime has altered the sediment budget of the marsh. Significant quantities of sediment may originate from upland sources which had previously not contributed to the sediment budget. Consequently, altered sedimentation rates in the marsh may result in impacts to first- and second-order channels. Currently, the persistence of these channels is unknown. However, these channels may be the most critical feature for maintaining multiple trophic levels of flora and fauna (including At-risk species). It is critical to understand and describe the physical controls dominating lower-order channel presence and perseverance.

Previous research has shown that lower-order tidal channels hydrologically function more like riverine watersheds (Pestrong 1965). Sedimentation and erosion rates are seasonally variable with respect to tidal processes and upland source sediments. In addition, biogeochemical processes, such as phosphate transformation and dissolved organic carbon (DOC) formation, may occur at higher levels due to higher concentration in the porewater, and as a result of the deposition and sorption of iron in surface soils in tidal channels of the upper marsh system (Chambers and Odum 1990).

This study will build on previous research and focus on the ecological processes that affect the structure and function of the brackish marsh tidal wetlands associated with first and second order tidal channels in a system containing third-, fourth- and potentially fifth-order channels (Figure 2). In addition, the study will incorporate a hierarchical structure on the scale of both the biotic and abiotic factors. The infrastructure of our conceptual model is shown in Figures 3 and 4, that present the key linkages between specific abiotic and biotic components we intend to measure in lower-order tidal channels in Suisun

Marsh. Our conceptual model also identifies an important link between substrate type and biotic factors. It has been shown that non-cohesive sediments are poor substrates for restoration (**Figure 5**) and can result in poor vegetation development due to the lack of the necessary nutrient conditions (Callaway 2001).

3. Approach

We will attain the goals and objectives of this project by answering a series of key questions (Table 1). These questions will be answered through field research and computer assisted modeling conducted as a series of specific tasks.

Task 1 - Biogeochemical Processes

Nutrient levels, transformation and availability are key to the productivity of the tidal marsh. However, data is needed to understand the processes in Suisun Marsh, and to resolve uncertainty about the likelihood of success for achieving specific restoration goals and objectives. Due to the complexity of the biogeochemical processes that occur in tidal wetlands, a reductionist approach will be used to identify key components and processes that significantly influence the biotic communities. The most commonly monitored water quality parameters at salt marsh restoration projects do not provide all of the needed data or attain the broad temporal and multivariate resolution available through inbenthic studies. Dissolved oxygen, pH, water temperature, and turbidity, unless monitored continuously, only give a partial representation of actual estuarine health. Therefore, we propose to conduct a year-long monitoring study to measure a broader range of parameters that have a significant role in ecosystem processes of tidal marshes.

A detailed water quality monitoring and QA/QC plan will be developed prior to the onset of sampling activities. At each site, we will measure the following water quality constituents: Temperature, pH, specific conductance, calcium (Ca), magnesium (Mg), potassium (K), salinity, sulfate, turbidity, total suspended solids (TSS), total nitrogen (N), nitrate, nitrite, ammonium, total phosphorous (P), phosphate, dissolved oxygen, biological oxygen demand (BOD), chlorophyll, total organic carbon (TOC), dissolved organic carbon (DOC) and total dissolved solids (TDS). Temperature, conductivity, pH, salinity, and dissolved oxygen will be measured at varying depths to generate a vertical profile. These measurements will be performed in the field using a YSI 556 meter. The instrument will be calibrated prior to each sampling run, and replicate measurements will be taken to evaluate precision. All other constituents will be grab-sampled for lab analysis, using appropriate methods specific to each constituent (e.g. proper container, appropriate quantity, pre-rinsing, and sample preservation), and submitted to a qualified lab for processing. Pre-existing water quality data will also be reviewed where available.

In addition to surface water in the sampled channels, subsurface constituents will be continuously measured with probes and autosamplers located adjacent to selected piezometers. Subsurface constituents will be identical to surface constituents with the omission of turbidity, TSS, and chlorophyll. The piezometers will be placed parallel and perpendicular to low order tidal channels at intervals to be determined from preliminary field measurements. Carbon dioxide production and cycling will be measured in surface and porewater, as well as soil-air flux. We will measure surface and porewater during tidal and storm periods with a carbon dioxide probe (Microelectrics Inc. Bedford, NH). Porewater will also be measured in the piezometers.

Task 2 - Sedimentation and Hydrology

Water surface levels (stage) will be constantly monitored at various locations and in various channels including low- and high-order channel. We will install a number of fixed gauges and pressure transducers. At each site, we will monitor: the short-term, three-dimensional velocity field using an acoustic Doppler profiler (ADP) or velocimeter (ADV) depending on depth of flow; local water depth; water temperature; water quality assessment; and the vertical turbidity profile using optical back-scatterance sensors (OBS). The vertical turbidity will be related to suspended sediment concentration using field-based calibration procedures in which bottled samples are acquired and analyzed in the laboratory via filtration and gravimetric methods.

In addition, long-term bed elevation changes will be monitored using a custom-manufactured sensor based on the PEEP design of Lawler (1991). These will be installed semi-permanently at each site with the PEEP and an artificial light column fixed to a metallic mount/anchor that will be inserted into the muddy substrate. The electrical cable leading from the sensor and light will be woven to a rope that will have a floating buoy attached to its end. It will house the waterproof connector that terminates the electrical cable. A small voltage-measuring and power-source module will be linked to the waterproof connector attached to the buoy. A single reading of the sediment level against the PEEP will be taken. At the same time, a portable instrument rack containing the ADV and OBS will be deployed, and these instruments will be burst sampled using a laptop-based data acquisition system. Each of the sites will be visited in the same sequence across the high tide and low tide stages. It will take about 10-15 minutes to locate, monitor, and re-locate sites. Although this is not precisely a 'synoptic' measurement scheme, it is probably the most effective method that can be performed without significant additional resources.

Samples will be taken under a variety of discreet conditions including, but not limited to; mean high-high tide, mean low-low tide, winter stormflow events, summer low flow periods, and mean high/low tides. Additionally, samples will be taken under a variety of seasonal and temporal variations including daylight and non-daylight periods.

Task 3 - Modeling for Hydrodynamic, Sediment Transport, and Water Quality Simulation of Micro-Channel Tidal Marsh Flows

Numerical modeling of flow, sediment transport, and water quality down to the micro-channel scale will be used to support planning of a monitoring strategy for the two marsh areas and will be developed toward the eventual goal of providing a predictive tool to facilitate future marsh restoration projects. The specific modeling objects include;

- Simulate flow in existing marsh channels down to micro-channel scale (~50 cm in width).
- Evaluate scour and deposition from tidal currents and intermittent upland flows.
- Evaluate the long-term stability of micro-channels.
- Simulate a minimal set of water quality constituents sufficient to characterize the Dissolved Oxygen concentrations in the water column.

The modeling will aid in understanding the relevant processes of flow and transport in the micro-channel system. It is not expected that the model will be used as an explicit predictor for the development of new micro-channels in a marsh restoration area.

The first phase of the modeling effort will be to support the design of the monitoring program. After the study site is chosen and initial surveys are completed, first cut models will be developed and will simulate flow, sediment transport, and water quality. The selection of water quality constituents will include those listed in Task 2. The early modeling results will be used to identify important locations at each site for monitoring activity.

A second phase of modeling will occur after one full year of monitoring activity. The second phase will focus on calibration to the observed data and refinement of the model formulation to better represent the actual field conditions. The model will run a variety of scenarios for both soil types. The model will predict water elevations, sediment deposition/scour, and water quality parameters. The model will be verified during the second year of monitoring activities. The models will be the basis for establishing the experimental treatments proposed in Phase III of this project.

Resources Management Associates (RMA) is prepared to apply the RMA finite element model of the San Francisco Bay and Sacramento-San Joaquin Delta. This model has been used in numerous studies of flow, sediment transport, and water quality throughout the system. The RMA finite element models were originally developed with the support of the U.S. Army Corps of Engineers Waterways Experiment Station (WES) for simulation of 1, 2, and 3-dimensional hydrodynamics, water quality and sediment transport in rivers, bays, and estuaries. These models form the basis of the Corps of Engineers' TABS modeling system. Most recently, the model has been used to evaluate impacts of potential levee breach scenarios in the Suisun Marsh region on flow and salinity both in the marsh and in the Delta. The unique capability of RMA model to utilize both one-dimensional cross sectionally averaged and two-dimensional depth-averaged geometry in a single computational network allows for a very effective spatial representation of a system as complex as the Bay-Delta. Because the model is based on the finite element numerical method, the spatial resolution of the computational mesh can vary over the network, allowing detailed representation of complex features – such as marsh study sites – without requiring an excessive level of detail in the entire network. The model also supports wetting and drying of elements, an essential capability when simulating marsh environments.

The focus of this project will be two small tidal marsh study sites of approximately one acre or less. The sites will be adjacent to tidal sloughs, which provide the sediment nutrient loading during dry weather periods. Storm events and/or agricultural runoff may provide sediment and nutrient loading from upland areas to the perimeter of the sites. One or more detailed finite element networks will be developed for the site and will be run both as a standalone model and as part of the full Bay-Delta model. The full network will be used to establish boundary conditions for the detailed site network.

The detailed networks will be based on site surveys and will represent channels down to 20-50 cm in width. Two approaches will be investigated for representation of micro-channel networks within the marsh study sites. First, the site will be represented as a network of one-dimensional channels. Off channel storage will be used to provide the required tidal prism above the top of the channels. Tidal influence will be propagated from the adjacent slough. Upland wet weather flows will be introduced at the ends of the first order channels at the perimeter of the marsh area. The second approach will be to represent the site using two-dimensional depth averaged elements with sufficiently fine spatial detail to resolve the first order channels. While this approach will provide a more direct solution when the marsh is inundated, the level of detail in the network is expected to require significant computational effort.

Task 4 - Structure of Biotic Communities

The abiotic factors and their linked processes have a significant effect on the development and productivity of tidal wetland vegetation. Wetland vegetation structure and function determine the structure and composition of the vertebrate wildlife. Wetland plant productivity (as measured as standing biomass) is correlated with availability of porewater phosphate and ammonium (Chambers and Fourqurean 1991). The concentration of these nutrients, while often higher in high marsh channels, is also dependent on the cation exchange capacity (CEC), which differs based on substrate cohesiveness (such as organic peat soils). In addition, the structure and composition of the invertebrate community in the low-order tidal channels is believed to vary with the type of substrate. This task will measure wetland vegetation, vertebrate and invertebrate community structure, and define the different substrate on which they are found. The variation in community and substrate will be correlated to the abiotic processes measured in the previous tasks.

Vegetation. Wetland plants are known to vary due to their proximity to tidal channels (Sanderson et al. 1999). We will measure vegetation composition and plant density quarterly along transects established parallel and perpendicular to low-order tidal channels. In addition, we will measure stem density of bulrushes and other cylindrical-leaved plants near the tidal channels. We will conduct a micromapping of the vegetation to develop a two dimensional spatial analysis of vegetation. Vegetation transects and plots will be placed in tandem with the sampling locations for Tasks 1 and 2. Direct measurements of vegetation will be made using a series of 50 meter line transects established parallel to the tidal channels. Measurements will be made to a minimum of 10 cm. for any particular plant or bare ground measurement. The endpoints of each transect will be staked so that repeated measurements can be made quarterly. The number of transects will be determine through preliminary measurements in the mapped vegetation areas. We conduct some preliminary transect measurements by temporarily placing a high density line transects then calculate the variance on the vegetation and bare ground cover. The number of transects will be determined by establishing a variance of no more than 5 percent. This will allow the highest level of accuracy of vegetation cover and repeatability. A larger area of vegetation analysis will be conducted using an existing GIS vegetation map developed by the Department of Fish and Game for Suisun Marsh. We will use the GIS data as a base map to evaluate plant associations and potential relationships with surface and subsurface hydrology.

The modeling in Task 3 will include a broad modeling base to allow analysis of overtopping during very high tidal periods and during winter storm events. This will allow for correlation of the GIS vegetation data with the hydrologic modeling. From our data and the DFG GIS vegetation database will be able to extrapolate some of our findings to other areas in Suisun Marsh. Field collected vegetation data will be analyzed using canonical correlation analysis, with the software package CANOCO (ter Braak 1987-1992). The vegetation data will also be correlated with the soil, hydrology, and biogeochemical data, again using CANOCO.

We will measure plant productivity by measuring photosynthetic rates using a LiCor 6400 photosynthesis device (LiCor, Lincoln, NB). Vegetation studies will be limited to measuring the dead vegetative material during the winter. In coordination with the biogeochemical studies on soil organic deposition (Task 1), we will measure rates of dead vegetation removal and decomposition. Seasonal variation in nutrient uptake of nitrogen and phosphorus will be determined by sampling and measuring dry weight plant material concentrations during the quarterly sampling periods.

Invertebrates. Many recent studies have examined ecological functioning between artificial and natural salt marshes, and found that replacement ecosystems are only marginally effective at approximating natural systems (Zedler et al. 1991). In one study (Zedler et al. 1991), functional deficiencies were found five years following marsh restoration in 10 out of 11 marsh parameters studied, including invertebrate abundance (36% of normal), invertebrate species diversity (78% of normal), and soil organic matter content (51% of normal). Impaired nutrient cycling and biological functioning are typical of restored marsh systems.

In a similar study, Sacco et al. (1994) found that inbenthic organisms and trophic group proportions were comparable between 1 to 17 year old artificially established North Carolina salt marshes and natural marshes. However, they noted lower total organism and trophic group densities within the artificial marshes. Suisun Marsh is not an artificially established marsh system, per se, but intensive historic uses and modified hydrologic conditions warrant further investigation into both nektonic (free swimming) and inbenthic (soil-dwelling) invertebrate support functions, particularly in relation to food chain support for vertebrate species following restoration projects.

This study will examine both the nektonic and infaunal communities associated with restored and natural wetlands in Suisun Marsh. There are three primary research objectives for this part of the proposed study:

- Examine and quantify the relative diversity and distribution of macroinvertebrate communities associated with both open water and bottom communities in manipulated and natural tidal salt marshes;

- Determine to what extent the macroinvertebrate communities in higher order channels resemble those of lower order channels, and;

- Investigate relationships between species composition and physical factors such as sediment and channel size.

Survey Methods and Collection Procedures - The focus of this study will be on using larger macroinvertebrates as a benchmark for marsh functioning. Surveys will be conducted quarterly over the course of the year to determine the availability of invertebrate forage during bird migration and stopover periods. Surveys would tentatively be conducted in the months of March, June, September, and December. The number of survey locations has not been determined, but would be based on the invertebrate findings for individual sites. For example, if too few invertebrates were identified to statistically satisfy the above research questions, the number of sites would be increased during the following sample session. Specific locations would be identified during a reconnaissance of the slough channels to identify the best-suited sites, particularly relative to sites that have been studied by other researchers.

As commonly required by the Center for Coastal Monitoring and Assessment and the NOAA National Ocean Service, differential treatment of samples will be based variable salinity conditions at the collecting site. Benthic samples from tidal-fresh and oligohaline salinity zones (0-5 ppt) will be treated differently from samples from mesohaline (>5-18 ppt), and euhaline (>30 ppt) salinity zones. Oligochaetes and chironomids from tidal fresh and oligohaline salinity zones will be identified to species (or lowest possible taxon) whereas individuals of these species from higher salinities do not need to be identified to the species level. The additional taxonomic effort required to identify these organisms to the species level produces important and useful information for the interpretation of benthic communities in tidal-fresh and oligohaline regions, but produces information of marginal value in higher salinity areas.

Benthic samples will gathered using a kick-net, and will also be pre-sieved in the field through a 4.0-mm mesh sieve to initially remove as much sediment and debris as possible. Samples will be re-sieved in the laboratory, sorted, and identified generally following the U.S. EPA *Environmental Monitoring and Assessment Program* (EPA, 1994). The objective of species identification and enumeration is to identify all organisms found in a sample to the lowest possible taxon and record the number of each organism. Specimens that are difficult to identify will be set aside in vials and preserved in ethanol for future identification.

The inbenthic invertebrate community will be sampled using a 6-inch Ponar grab sampler (0.02 m^2) to collect three subsamples at each of sampling station. Samples will be collected concurrently with the collection of nektonic samples (described below). Grab samples from each location will be consolidated and screened in the field through a 4.0-mm sieve. Collected invertebrates will be preserved in 70 percent ethanol, transported to the laboratory and carefully tracked by sample number.

Nektonic invertebrates will be sampled using a 5-inch Wildco Fieldmaster plankton net with an 80-micron mesh size. Three subsamples (one near the water surface, one at approximately half-depth, and one near the bottom of the channel) will be collected at each sampling station through 5-minute trawls. Subsamples will be consolidated and preserved in 70 percent ethanol and transported to the laboratory for identification to the lowest practical taxon using Smith and Carlton (1975), Light (1978), and Usinger (1968).

Analysis - As an initial means for analyzing samples, invertebrate species data will be grouped within sample regions and by channel type to facilitate the comparison of conditions between regions. A one-way multivariate analysis of variance (MANOVA) will be used to examine regional differences in dependent variables: species richness and abundance, and other analyzed physical parameters of the collection sites. Canonical correlation will be used to determine the best possible relationships between invertebrate attributes and environmental variables. From this assessment, a model will be developed to predict invertebrate use of slough channels based on the history of disturbance (restored or natural) and relative order (small versus large) of the slough channel. Such an assessment will serve to predict the relative quality of the slough channel in terms of invertebrate productivity and food production for higher order organisms.

Vertebrates. Observations on bird use and species abundance will be conducted to assess vertebrate community structure. Information IS being gathered in other studies being conducted in Suisun Marsh by DWR, DFG, and other CALFED-funded projects will used to augment our information. Vertebrate studies will conduct field observations quarterly. Avian studies will include establishing 5 point count sample locations immediately adjacent to the two tidal channels being studied. In addition, 5 standard point count sites will be established in the larger (approximately 0.5 hectare) area surrounding the channels. Observations will include species and behavior within 50 meters of the point during a 5 minute interval. Small mammal trapping will not be conducted since data will be available from other studies. The primary linkage of the vertebrate data will be with the plant community structure and spatial variation in the study area. We will use multivariate canonical correlation analysis, using CANOCO (ter Braak 1987-1992), to conduct the correlation analysis.

Task 5 - Integrated Restoration Design Model and Restoration Plan

Following the collection and analysis of field data, and the development and analysis of the RMA model, we will develop an integrated ecosystem/physical process restoration design model for low-order channels in Suisun Marsh. We will identify the key abiotic and biotic factors and the linkages between them. Our field measurements, analyses and RMA's modeling will have identified the most significant linkages between the abiotic factors and which ones are controlling the vegetation and other biotic community components. The integrated plan will focus on the parameters that can be controlled as part of a restoration project and how to integrate restoration activities within the natural tidal and other processes that are present. We anticipate creating and integrated restoration design tool and conceptual model that provides a better understanding of the relationship between substrate, nutrients and vegetation through the growing season. The more detailed understanding of the relationships found within the system will provide information on implementing restoration projects, and methodologies on how to better achieve restoration goals on non-cohesive substrates.

The integrated restoration design plan will include the following key elements derived from the comprehensive studies and analyses:

- Quantitative levels of annual inputs of nutrients, sediments, and organic materials,
- Quantitative levels of annual outputs of nutrients, sediments, and organic materials,
- Quantitative levels of annual nutrient transformations and cycling within the channels system and the vegetation,
- Quantitative linkage between cohesive and noncohesive sediments and nutrients and the effect on the vegetation and invertebrates,
- Quantitative linkage between sediment rates and erosion rates and vegetation and invertebrates, and
- Effect of seasonal variation of upland winter storm-related sediments and nutrients on vegetation structure and growth and tidal channels,

The restoration component of the plan will include the following model parameters for implementing the pilot/demonstration:

- Identify a target low-order tidal channel width and depth that will be created,

- Identify how the rates of annual sedimentation and erosion will vary within the created channel based on models so that it can be assessed relative to control channels,

- Identify the plant species that will be planted (for pickleweed we will use seed which has a higher rate of establishment) . We anticipate that we may create one channel and allow natural vegetation processes to occur in order to evaluate difference in vegetation establishment, erosion, and sedimentation.

- Identify expected outcomes of invertebrate establishment and evaluate the potential to establish an invertebrate system by adding particular native species,

- Identify expected rates of biogeochemical processes as the tidal channel is created and equilibrates from tidal flux and upland hydrological and sediment inputs,

- Identify a specific sequence and timing of biogeochemical, hydrological, and sediment deposition or erosion processes to occur over a 3 year period for the proposed experimental restoration,

- Identify performance measures based on the quantitative measures for abiotic processes equilibration, and

- Identify performance measures for vegetation and invertebrate community establishment and growth.

The restoration design model also will identify the steps that we intend to take to implement pilot/demonstration restoration experiments in Phase 2. Those experiments will be used to test the validity of our integrated models and the significance of the abiotic factors that we ultimately decide and determine biotic outcomes of the restoration effort. The restoration design plan will also include a detailed monitoring plan and adaptive management section, and develop specific performance standards that the restoration must meet to be considered successful. The goal of the integrated restoration design model will be to restore low-order tidal channels at an accelerated rate so that they become equilibrated with the marsh quicker. Through the model and the pilot restoration we will be able to determine what factors can be manipulated to establish equilibrium and natural processes.

4. Feasibility

The team of scientists that have been organized for this effort are recognized experts that have dealt with the complex issues similar to those addressed by the proposed project. CALFED has determined that interdisciplinary studies such as is proposed must be conducted to reduce the uncertainties found within these complex ecosystems, and to the specific conditions at Suisun Marsh. We have significant interest and support from State and Federal agencies including the Department of Water Resources, Department of Fish and Game, and the U.S. Fish and Wildlife Service. These agencies have promised to help us coordinate with the Suisun Marsh Planning Committee and identify study sites in Suisun Marsh through the developing Charter Program.

As this project is restricted to research, CEQA/NEPA and other regulatory requirements do not apply. Members of the project team hold scientific collection permits.

5. Performance Measures

All our studies will be available for peer review. There are several steps in our approach that will require careful examination of the methods prior to implementing each of the proposed tasks. Preliminary field studies will provide water and soil samples to determine the ranges of concentrations. Also, preliminary modeling by RMA using existing hydrology, sediment and water quality data will allow us to coordinate the year-long field measurements to provide the best data to recalibrate the models. Performance will be evaluated by quantifying the successful collection of data and generation of models, as well as the timely production of planned deliverables.

6. Data Handling and Storage

Data will be maintained at Environmental Science Associates. Mapping will be conducted using Environmental Systems Research Institute software to ensure transportability. All field samples will follow standard QA/QC and chain-of-custody procedures. All data will be provided to CALFED as part of quarterly and technical reports, and made available to other interested parties upon request.

7. Expected Products/Outcomes
8. Work Schedule

The expected products, including reports, and the schedule of their production, is listed in Table 2. The models and understanding generated by this project will represent a significant advance in technology for restoration of lower-order channels and obligate At-risk species.

B. Applicability to CALFED ERP and Science Program Goals and Implementation Plan and CVPIA Priorities

1. ERP, Science Program and CVPIA Priorities

Our proposed project will meet significant CALFED program needs (Figure 3).

<u>Milestones for the Suisun Marsh and North San Francisco Bay, from the Multi-Species Conservation Strategy.</u>

Increase Overall Population Size of Suisun Thistle at Least Threefold - This project will help develop the understanding and tools necessary to support restoration of suitable habitat for the Suisun thistle, and increase population sizes.

Restore a Minimum of 400 Acres of Tidal Perennial Aquatic Habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone **-** This project will provide the fundamental information required for CALFED to achieve this goal. Results from this effort will establish the principles for implementing all future restoration efforts of micro-channel habitat in Suisun Marsh and will likely be applied to restoration efforts in the rest of the Delta region.

ERP Strategic Goals

Goal 1 - At-Risk Species. Monitoring, assessment, research, and a demonstration project will be conducted to improve the understanding of the ecological and physical processes in muted tidal marshes affecting at-risk species. The resulting food web and sediment transport models will help improve the mechanistic understanding of this and other similar ecosystems related to at-risk species. Restoration and adaptive management strategies will also be developed to help foster at-risk species recovery. Recovery of the following species will be supported by the restoration effort: soft bird's beak, Suisun thistle, Central Valley fall-/late-fall run chinook salmon, delta smelt, Delta green ground beetle, and Salt Marsh Harvest Mouse.

Goal 2 - Ecosystem Processes and Biotic Communities. Knowledge of the physical processes related to sediment transport will be improved, and an understanding the mechanisms underlying native species responses to hydrologic processes will be developed. Monitoring will be carried out that evaluates food web structure and sediment and pollutant transport. The project will also resolve uncertainty regarding how geomorphic processes take place under a muted tidal regime. This effort will examine opportunities to improve modified flow regimes to support ecosystem process and communities; the project seeks to rehabilitate the natural processes in the lagoon in ways that favor native members of the community by identifying adaptive management and restoration strategies that require minimal human intervention. Opportunities to restore historic channels will also be examined.

Goal 4 - Habitats. This project supports restoration of multiple functional habitat types, both through an increased understanding of the mechanisms supporting various habitats, and the development of methods for fostering those habitats. The following habitat types will be addressed: tidal saline marsh, perennial tidal shallow open water aquatic, and associated upland and nearby riparian habitats. The project will also address information needs surrounding the utility and success of restoring shallow water and tidal/marsh habitat through modification of hydrologic regimes.

Goal 6 - Sediment and Water Quality. The monitoring and management strategies to be developed in this project will improve water quality and our understanding of sedimentation processes in this highly human-impacted ecosystem. Uncertainty will be resolved regarding the links between sedimentation regimes, contaminant transport, management of flows, and wetlands restoration.

CALFED Science Program Goals

Develop Performance Measures - Performance measures will be developed for all aspects of the project, and the project approach will be modified in response to performance on an ongoing basis.

Advance Process Understanding - The project will develop conceptual ecosystem models that will help us understand the processes guiding muted tidal and shallow-water habitat, and associated restoration opportunities.

Establish Integrated Science Programs in Complicated Field Settings - The project addresses the many complicated aspects of the ecosystem by using an interdisciplinary approach toward achieving goals.

Disciplines will include hydrology, biogeochemistry, biology, ecology, and geomorphology. The applicant team consists of regulatory agencies, academic institutions, and private consultants.

Advance the Scientific Basis of Regulatory Activities - The program will help develop a scientific basis for its management activities in the lagoon. The science-based management strategies will also have application to similar ecosystems elsewhere.

Restoration Priorities for the Bay Region

1. Restore Wetlands in Critical Areas Throughout the Bay by Improvements that Add to Existing Projects - The project will aid in the restoration of marshes within Suisun Bay, which will provide direct benefits for endangered marsh species.

5. Restore Shallow Water, Local Stream, and Riparian Habitats for the Benefit of At-Risk Species While Minimizing Potential Constraints to Successful Restoration Efforts - This project will model and perform physical measurements that detail how freshwater and brackish water interact. It will also examine the spatial and temporal viability of structure and dynamics of tidal wetland plant communities, including relationships to floodings, soil salinity, soil pH, and channel water salinity. It will also shed light on the edaphic requirements for sensitive plant species.

6. Protect At-Risk Species in the Bay Using Water Management and Regulatory Approaches - This project seeks to increase understanding regarding the marsh and similar habitats, and will provide a scientific basis for the development of regulatory approaches such as water management. Areas of uncertainty to be addressed will include the food web at the marsh and the factors controlling it structure, function, and productivity; the connection between the marsh and adjacent habitat; primary and secondary productivity within the marsh; and linkages among internal and external inputs to the marsh. Through the development of an effective science-based management strategy, at-risk species will be protected.

7. Improve Scientific Understanding of the Linkages between Populations of At-Risk Species and Inflows - In the proposed project, physical measurements to evaluate flow, sediment transport, and hydronamic patterns will be carried out in conjunction with the development of hydrologic and sediment transport models. Factors such as short-term sediment deposition patterns will then be linked to biological response in the ecosystem, including that of at-risk species. Our corresponding understanding of water quality and ecosystem processes, the resulting hydrologic regime, and at-risk species, will be increased. These sediment and hydrologic models will then be used as restoration tools to identify appropriate strategies to encourage populations of at-risk species.

8. Use Monitoring to Develop Improved Strategies for Restoring Bay Fish Populations and At-Risk Species - We will be developing an integrative monitoring approach that will provide new understandings on which to base restoration strategies for populations of at-risk species. Linking an understanding of the ecological processes to a restoration and management approach will help ensure the success of ongoing efforts.

2. Relationship to Other Ecosystem Restoration Projects

This project will dovetail with several other important CALFED-funded projects including 1999-B13 Understanding Tidal Restoration Processes and Patterns. That project is primarily looking at restoration processes that are larger in scale than the proposed project. The hydrological processes in that study are significantly different and the tidal prism is not conserved in the higher-order channels they are studying for potential levee breaching. Our project will, however, benefit from that study by coordinating our biological studies so that we can ultimately link the plant and wildlife community data and create a tidal channel continuum. Further, our study proposes to conduct studies on hydrology, biogeochemistry and modeling that are focused on the low-order channel systems and evaluate the difference between cohesive and noncohesive sediments and the role they may have in restoration. As such, the proposed investigation will complement the existing project and provide an additional level of data and analysis.

3. Requests for Next-Phase Funding

Not applicable.

4. Previous Recipients of CALFED Program or CVPIA Funding

Not applicable.

5. System-Wide Ecosystem Benefits

Our studies will provide important information on salt, brackish and freshwater tidal marsh systems due to the level of information being studied. The information will be particularly useful to develop and inform restoration projects in brackish and saltmarsh systems through the CALFED region and elsewhere. As a result, this project expects to produce benefits to the various At-risk species that are dependent on lower-order channels.

6. Additional Information for Proposals Containing Land Acquisition

Not applicable.

C. Qualifications

The project team for this effort is composed of an interdisciplinary public/private partnership which includes a public agencies, private consultants, and academic institutions. The project will be administered by Environmental Science Associates, which has over 31 year's experience at project management and the completion of similar studies. Other organizations represented include University of San Francisco, University of Southern California, U.S. Bureau of Reclamation, and Resource Management Associates.

Niall McCarten, Ph.D. will be project manager and provide expertise in wetland ecology. He is senior biologist with Environmental Science Associates and Research Associate with the Section of Plant Biology at UC Davis, and the UC Jepson Herbarium at UC Berkeley. He received his B.A. in botany at UC Santa Barbara, M.A. in Ecology and Systematics at San Francisco State University, and Ph.D. in botany at UC Berkeley. He is a nationally recognized botanist and plant ecologist with peer reviewed papers and conference presentations on rare and endangered plants, wetlands ecology and monitoring. He has over 15 years experience conducting research and monitoring on vernal pools and the associated rare plants and wildlife. He has served as the project manager on many large projects involving teams of scientists, resource agency staff, and consultants. He was one of the few non-public agency scientists asked to participate in the development of the original CALFED Ecosystem Restoration Program (ERP) plan, participated in the development of the CALFED Multispecies Conservation Strategy (MSCS).

Matt Zidar will be project director and hydrologist. Mr. Zidar is the Director of ESA's Northern California office and of the Water and Wastewater Services Group in Sacramento, CA. He has over 17 years of management and technical assessment experience on a wide range of water resource and wastewater management programs. Mr. Zidar has expertise in water resources planning, engineering, and project management, hydrology, groundwater analysis, flood control, reconnaissance and feasibility studies, wellhead protection, water conservation, geographic information system GIS/DBMS applications in water resources, water quality analysis, water rights, wetlands permitting and assessment, environmental compliance, CEQA, NEPA, public involvement and meeting facilitation. Prior to joining ESA, Mr. Zidar was Principal Hydrologist/Project Manager at Jones and Stokes Associates for four years, and served as Manager of the Water Resources Division and Principal Hydrologist for the Monterey County Water Resources Agency over a ten year period. As Manager, Mr. Zidar was responsible for directing technical investigations for groundwater and surface water development, data collection, reservoir operations, groundwater and surface water modeling, development of water supply and water quality policies, conservation plans and policies, CEQA review, and implementation of Agency ordinances and regulation for groundwater extraction. He holds a B.S. in Watershed Sciences and Hydrology from Colorado State University.

John Callaway, Ph.D. will provide expertise in the area of wetland and restoration ecology. Dr. Callaway currently serves as a Professor at the Department of Environmental Sciences at the University of San Francisco. He was previously a Professor and Associate Director of the Pacific Estuarine Research Laboratory (PERL) which specializes in coastal wetland restoration. He holds a Ph.D. in Oceanography and Coastal Sciences from Louisiana State University with an emphasis in wetland ecology. Dr. Callaway's research at PERL includes evaluating the relationship between plant diversity and ecosystem function in restored coastal wetlands, assessing the success of wetland restoration projects based on a comparison of vegetation and soil characteristics at restored sites and natural reference sties, and assessing impacts of sedimentation on the Tijuana Estuary. Dr. Callaway has also been involved in the planning and implementation of experimental salt marsh restoration efforts at the Tijuana Estuary. His research interests include wetland plant and soil ecology, with focus on the effect of plant species diversity on ecosystem functioning, development of restoration and assessment methods for wetland ecosystems, and sediment dynamics.

John DeGeorge, Ph.D. will perform hydrological modeling. Dr. DeGeorge has been actively involved in the field of hydrodynamic and water quality modeling during the past 12 years through his association with Resource Management Associates (RMA) and as a post graduate research engineer at U.C. Davis. He has applied, developed and enhanced RMA's suite of multi-dimensional finite element models for flow, water quality and sediment transport. He served as project manager for RMA's numerical modeling of levee breaches for the CALFED Suisun Marsh Levee Investigation Team. He is project manager and the lead designer for software development in support of the U.S. Army Corps of Engineers'

Hydrologic Engineering Center's (HEC) new real-time water control data system. Dr. DeGeorge received a B.S., M.S., and Ph.D. in civil engineering.

Donald Smith, P.E., Resource Management Associates, will also perform hydrological modeling. Mr. Smith has over 30 years experience and has been responsible for a wide variety of projects involving the development and application of sophisticated hydrodynamic, thermal, water quality and sediment transport models for estuaries, streams and reservoirs. He has been responsible for numerous two-dimensional model evaluations for flow, water quality and sediment transport in the San Francisco Bay-Delta system. These include outfall studies for the City of San Francisco, the City of Palo Alto and the Novato Sanitary District, and the sediment studies for several existing and proposed Delta marinas. Together with DWR, he was responsible for development of the RMA-DWR link-node model of the Delta, and applied a modified version of the model for the evaluation of the Delta Wetlands island water storage project. Mr. Smith received a B.S. in civil engineering and is a registered professional engineer in the State of California (#18,041).

Bernard Bauer, Ph.D. will provide expertise in the area of sediment deposition and erosion. Dr. Bauer is Professor and Chair of the Department of Geography at the University of Southern California. He is a process geomorphologist who received his Ph.D. from the Whiting School of Engineering at the Johns Hopkins University. He serves on the editorial boards of *Geomorphology* and *Annals of the Association of American Geographers (Environmental Sciences)*. Between 1997-99, he was the Program Director of the Geography and Regional Science Program at the National Science Foundation where he also co-directed the interagency (EPA/NSF/USDA) Water and Watersheds Program. His research is in the area of fluid-sediment interactions in coastal, fluvial, and aeolian environments with special focus on the coupling between sediment transport processes and the evolution of mesoscale landforms. Over the past five years, he has been involved in a project directed at understanding the hydrodynamics of boat-generated waves and quantifying their long-term impact on the chronic levee-bank erosion problem in the Delta. Professor Bauer teaches undergraduate courses in all aspects of physical geography as well as graduate courses in the mechanics of sediment transport and boundary layer dynamics.

Erwin Van Nieuwenhuyse, Ph.D. will provide expertise in water chemistry, statistics, and monitoring. Dr. Van Nieuwenhuyse is a limnologist and senior fisheries biologist with the US Bureau of Reclamation and a Visiting Research Scientist with the Department of Land, Air and Water Resources at the University of California, Davis. He received his B.S. in Zoology from Michigan State University, M.S. in Fisheries Biology from the University of Alaska, Fairbanks, and Ph.D. in Limnology from the University of Missouri, Columbia. He is an internationally recognized expert on lotic and lentic biogeochemistry and presently serves as the Mid-Pacific Region's chief scientist on water quality and fisheries-related issues for the California Central Valley Bay-Delta ecosystem. He also co-manages, with the California Department of Water Resources, the Interagency Ecological Program's Bay-Delta Environmental Monitoring Program.

Arnold Gerstell, Ph.D. will provide expertise in the area of wildlife. Dr. Gerstell is a vertebrate ecologist at Environmental Science Associates, with an emphasis on the study of birds. He is experienced in field surveys, the collection and analysis of data, and the preparation of technical biological reports, and has published a number of papers in professional journals. His project experience at ESA includes assessment of wildlife habitat values for The Forest of Nisene Marks State Park general management plan, the Coast Dairies Long-Term Resource Protection and Use Plan, and others. He is currently lead biologist in the preparation of management plans for four Ecological Reserves owned by the California Department of Fish and Game. These plans include description of current reserve conditions, development of alternatives for desired future conditions, and determining the monitoring effort required for effective adaptive management of the reserves. Mr. Gerstell has prepared numerous environmental reports under federal and State of California environmental laws, and is familiar with the problems of communicating biological information to the public through his previous work as a university lecturer in ecology and environmental studies. He received a Ph.D. in Biology from Idaho State University, a M.S. in Biology from University of New Mexico, and a B.A. in Biology from University of California at Santa Cruz.

Brian Pittman will provide expertise in invertebrate sampling and analysis. Mr. Pittman is a senior wildlife biologist at Environmental Science Associates. He has directed similar multi-year salt marsh studies in Napa County and in the San Francisco Peninsula marshlands. His Master's thesis, *A Survey of Inbenthic Macrofauna at a South San Francisco Bay Salt Marsh*, examined the distribution of inbenthic macroinvertebrates in relation to physical soil parameters at an undisturbed reference marsh and managed mudflat twelve years following tidal restoration. Mr. Pittman's background is in wildlife and restoration ecology, and environmental law. He has over four years in wetland restoration and ecology, implementation and monitoring. He specializes in wildlife and wetland ecology, CEQA/NEQA compliance, and has statewide environmental assessment experience. Non-native species management, environmental sampling design, environmental restoration, and mitigation and monitoring design are additional emphases. He has performed plant and wildlife surveys, assessments, and monitoring at field sites in Southern California, the Central and Sacramento Valleys, and in the San Francisco Bay Area and North Bay. He has a M.S. in Environmental Studies from San Jose State University and a B.A. in Biology from University of California, Santa Cruz. He also holds a 40-hour Health & Safety OSHA Certification, a California Scientific Collecting Permit (#801090-01), and has completed the U.S. Army Corps of Engineers' Wetland Delineation Training Course.

Erich Fischer will provide expertise in the area of wildlife. Mr. Fischer is a senior biologist with Environmental Science Associates, and serves as a technical analyst for a variety of projects. He specializes in environmental assessments, environmental impact statements, and biological assessments. He received his B.A. in Biological Sciences from UC California, Sacramento. Mr. Fischer is also skilled in field surveys for many California listed species, habitat modeling on GIS systems, ecological monitoring and restoration, and habitat delineation. Mr. Fischer is expert in the requirements of the CEQA and the NEPA, and in the preparation of environmental documents.

Thomas Trexler will examine water quality. Mr. Trexler specializes in hydrology and analytic chemistry. His understanding of water resource issues spans across the policy forum and the laboratory. He is fully competent in limnological and riparian sampling, laboratory analysis, hydrologic flow sampling, and GIS analysis. His background includes interdisciplinary analyses of water quality at a variety of scales ranging from microscopic to meso-scale catchments. Mr. Trexler has over 6 years of experience within industrial settings as an engineering liaison, a hazardous materials handling specialist, and an emergency response protocol tactician. He has an additional 3 years of experience with hydrology and aquatic chemistry as a graduate research assistant. Mr. Trexler is trained and familiar with many analytic procedures including ion chromatography, mass spectroscopy, inductively couple plasma gas chromatography, atomic absorption, and stable isotope separation and detection. In addition to his training as a fluvial geomorphologist, he is a water quality expert with applications that include watershed evaluations, total maximum daily loads (TMDL), pollution prevention plans (BMPs), flow analysis, water use/demand calculations, and impact/mitigation analyses to name a few. He received an M.S. in Hydrology and Aquatic Chemistry from Yale University, and a B.S. in Environmental Science from the University of Southern California.

Chris Rogers will be responsible for wetlands ecology. Mr. Rogers is a wetlands and plant ecologist at Environmental Science Associates with over 12 years' experience conducting habitat assessments, endangered species evaluations, preparation of environmental documentation and permitting applications, restoration and mitigation planning, and construction monitoring. He is particularly adept in wetlands restoration design and implementation. Mr. Rogers has applied his scientific knowledge and permitting know-how on numerous projects across the State of California. His experience working with wetlands design and construction in Bay Area wetlands includes preparing restoration and revegetation plans for Alhambra Creek in Martinez involving extensive planting of a native cordgrass marsh, developing long-term marsh and riparian habitat restoration concepts as part of the City of Napa's Master Plan for John F. Kennedy Park, and designing, supervising implementation and monitoring of tidal wetland restoration projects at the Chevron Richmond Refinery in Richmond. In addition, Mr. Rogers has conducted numerous site assessments of wetlands and streams and feasibility studies for restoration, enhancement and water treatment applications. He received a B.A. in biology/botany at San Francisco State University.

Thomas Leeman will be responsible for biological monitoring. Mr. Leeman is a biologist at Environmental Science Associates with expertise in ornithology and wildlife ecology. He is skilled in performing terrestrial wildlife inventories, vegetation surveys, and salmonid monitoring, and applying GIS and statistical methodologies for data analysis. His extensive experience working as a field biologist for private companies, Federal and State agencies, and in the non-profit sector, make him especially sensitive to the objectives and requirements of these diverse organizations. Mr. Leeman possesses a working knowledge of the provisions and requirements of the CEQA and NEPA as they relate to the preparation of environmental documents. He received an M.S. in natural resources (wildlife) from Humboldt State University, and a B.S. in biological science from the University of California, Davis. He has also completed a 38-hour USACE Wetland Delineator Certification Program Course.

D. Cost

1. Budget

The total estimated cost for the two-year project will be $1,791,360. For details, please refer to the online forms.

2. Cost-Sharing

Not applicable.

E. Local Involvement

This project has the support of the Suisun Marsh Restoration Team that includes the California Department of Water Resources. The project will be coordinated with on-going studies in Suisun Marsh including CALFED funded studies, and will coordinate with the Suisun Marsh Charter Organization. We will also coordinate with local agencies including the Fairfield-Suisun Sewer District, and Solano County Open Space and Agriculture Protection Conservancy.

F. Compliance with Standard Terms and Conditions

If this project is funded it will comply with all state and federal contract standard terms and conditions identified in the Proposal Solicitation Package, Attachments D and E.

G. Literature Cited

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Table 1. Tasks, Activities, and Key Questions

Tasks and Activities	Key Questions
Task 1 - Biogeochemical Processes	
Nutrient dynamics	What are the diel and seasonal nutrient changes that occur within small tidal channels?
	What is the effect of seasonal storm water runoff to the nutrient budget.
	What are the nutrient gradients at different levels within the substrate relative to the distance from tidal channels?
Task 2 - Sediments and Hydrology	How do sediment deposition or erosion rates vary with respect to channel size?
	What are the sediment deposition or erosion rates on the flats adjacent to the tidal channels?
Sediment Types	How are nutrient dynamics affected by sediment composition (cohesive vs. non-cohesive sediments)?
Channel Width and Depth	What is the relationship of channel width and depth on diel and annual tidal flows?
Subsurface	What is the subsurface direction and rate of flow during diel tidal fluxes?
Task 3 – Modeling for Hydrodynamic, Sediment Transport, and Water Quality Simulation of Micro-Channel Tidal Marsh Flows	
Task 4 - Structure of Biotic Communities	
Plant Structure and Tidal Channels	How does plant species composition and structure change in relation to tidal channel size?
	How does plant species composition and structure change with respect to their distance from tidal channels?
Non-native Invasive Plant Species (NIS)	What biotic and abiotic factors are correlated with or promote NIS.
Invertebrate Composition	What are the differences in invertebrate densities and composition in different sized channels?
	How is the invertebrate community influenced by substrate?
Vertebrate Species Use	What is the composition of vertebrates associated with small tidal channels?
Task 5 – Integrated Restoration Design Model and Restoration Plan	What key abiotic and biotic factors need to be used to restore low-order tidal channels?
	What is the affect of spatial and temporal scale in creating particular tidal channel systems?

Table 2. Activities, Products/Outcomes, and Work Schedule

Activities and Products/Outcomes	Work Schedule
Task 1 - Biogeochemical Processes	August 2002 to October 2002. This task will be initiated within the first month of funding to collect preliminary sample data for the purpose of determining the location and distance between sample points along and away from the tidal channels.
	November 2002 through October 2003. Once sampling sites have been established monitoring will be conducted quarterly for a 12 month period.
Report: A summary report will be developed on the findings	December 2003
Task 2 – Sedimentation and Hydrology	November 2002 through October 2003. Once sampling sites have been established monitoring will be conducted quarterly for a 12 month period.
Report: A summary report will be developed on the findings	December 2003
Task 3 – Modeling for Hydrodynamic, Sediment Transport, and Water Quality Simulation of Micro-Channel Tidal Marsh Flows	August 2002 through November 2002 Preliminary modeling using existing information and measurement of the tidal channels to be studied will conducted.
	December 2003 through April 2004 Second phase and recalibration of models based on data collected in Tasks 1 and 2.
Report: Summary report on model findings	May 2004
Task 4 - Structure of Biotic Communities	November 2002 through October 2003 Conduct field studies quarterly
Report: Summary report on findings	January 2004
Task 5 - Integrated Restoration Design Model and Restoration Plan	March 2004 through May 2004 Conduct analyses and develop draft plan
Report: Final Plan	July 2004

Figure 1
Suisun Marsh

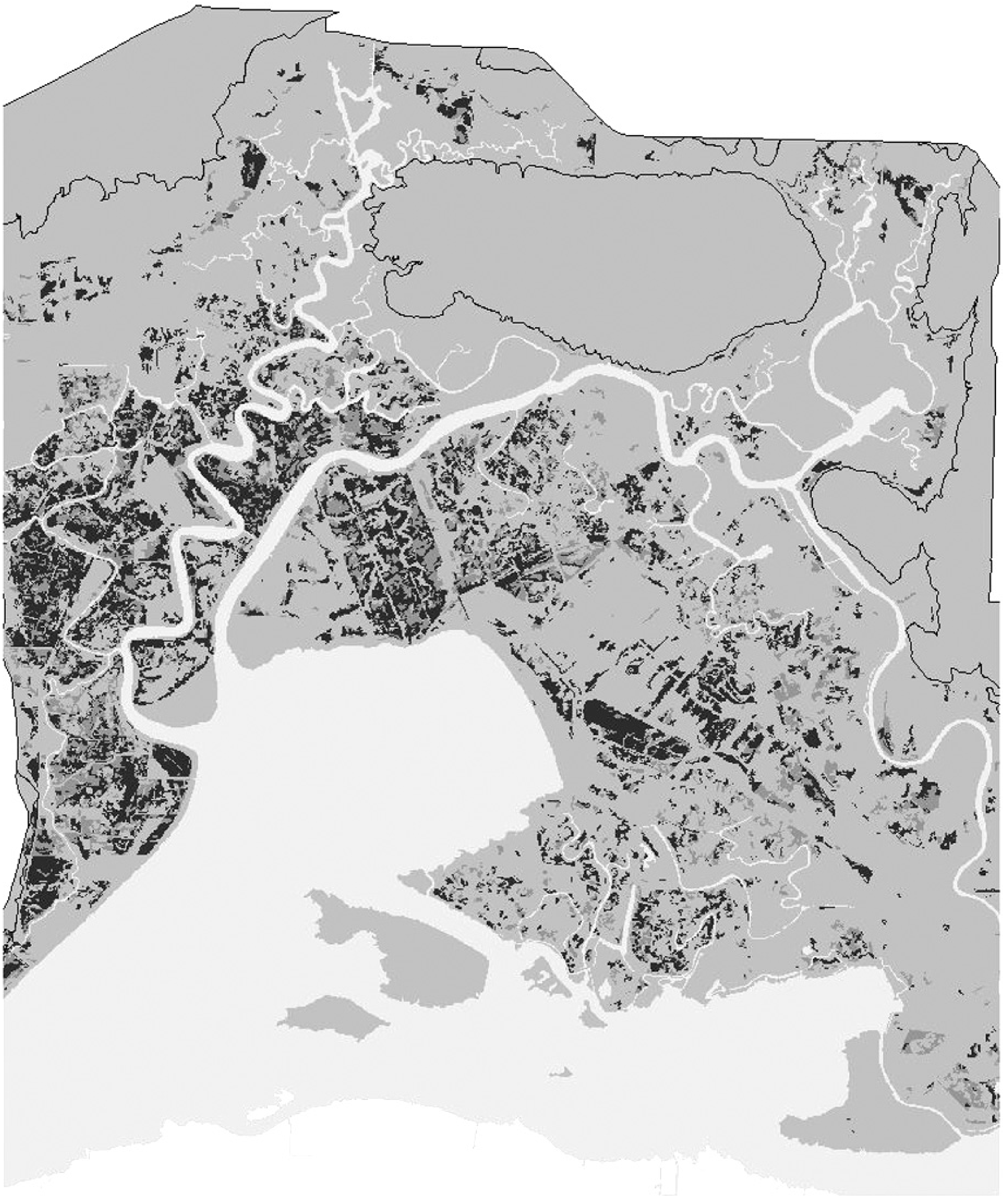
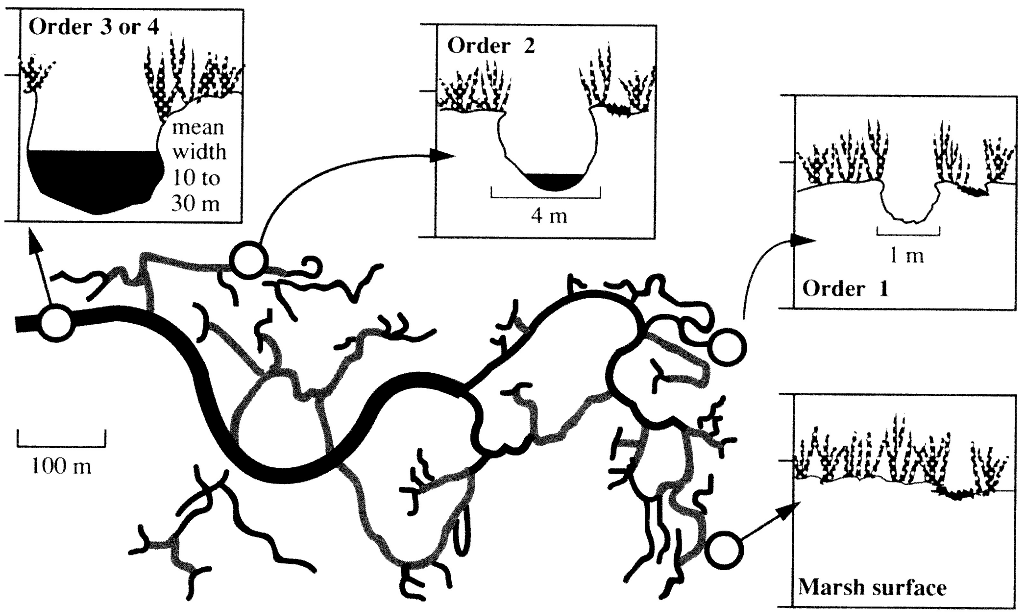


Figure 2
Tidal Channel Structure



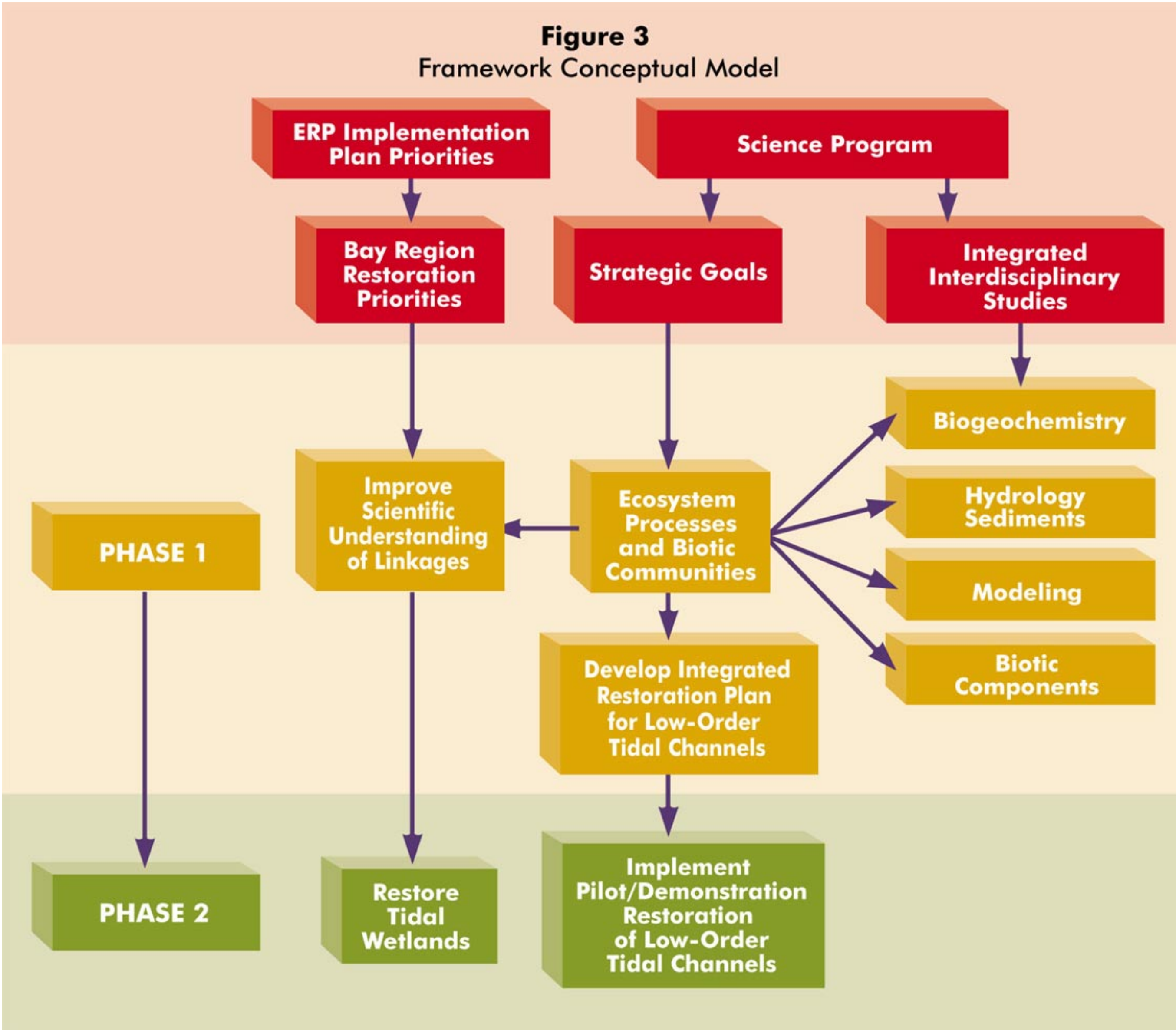


Figure 3
Framework Conceptual Model
ERP Implementation Plan Priorities
Science Program
Bay Region Restoration Priorities
Strategic Goals
Integrated Interdisciplinary Studies
Biogeochemistry
Improve Scientific Understanding of Linkages
Ecosystem Processes and Biotic Communities
Hydrology Sediments
PHASE 1
Modeling
Develop Integrated Restoration Plan for Low-Order Tidal Channels
Biotic Components
PHASE 2
Restore Tidal Wetlands
Implement Pilot/Demonstration Restoration of Low-Order Tidal Channels

Figure 4
Infrastructure Conceptual Model

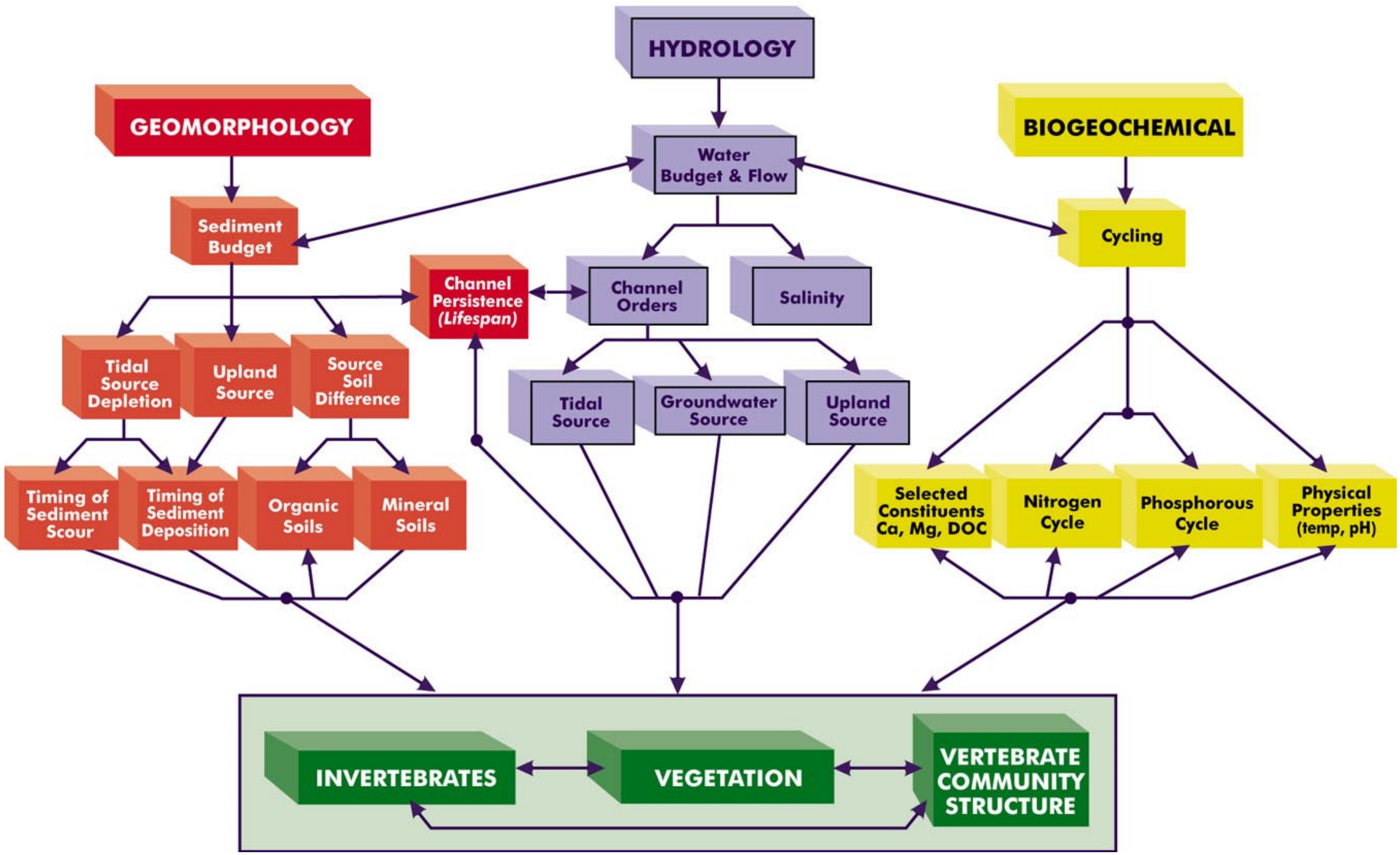


Figure 5
Hydrological and Substrate Factors and Restoration Process