Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

Project Information

1. **Proposal Title:**

   Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

2. **Proposal applicants:**

   Ronald Tjeerdema, University of California, Davis

3. **Corresponding Contact Person:**

   Ahmad Hakim-Elahi
   University of California Davis
   Director of Sponsored Programs Office of the Vice Chancellor for Research Sponsored Programs,
   118 Everson Hall University of California One Shields Ave Davis, CA 95616-8671
   530 752-2075
   vcresearch@ucdavis.edu

4. **Project Keywords:**

   Environmental Risk Assessment
   Heavy Metals (mercury, selenium, etc.)
   Wildlife-friendly Agriculture

5. **Type of project:**

   Research

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

   No

7. **Topic Area**:

   Uplands and Wildlife Friendly Agriculture

8. **Type of applicant:**

   University

9. **Location - GIS coordinates:**

Latitude:	n/a
Longitude:	n/a
Datum:	n/a

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

Proposal study encompasses both of the Sacramento and San Joaquin Valley regions

10. **Location - Ecozone:**

    Code 15: Landscape

11. **Location - County:**

    Butte, Colusa, Fresno, Glenn, Merced, Sacramento, Shasta, Stanislaus, Sutter, Tehama, Yolo, Yuba

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:**

    2, 3, 5, 18, 11, 19, 20

15. **Location:**

    California State Senate District Number: 1, 4, 6, 5, 12, 16, 14

    California Assembly District Number: 8, 9, 26, 17, 10, 5, 2

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?

       Yes

       If yes, list the different overhead rates and total requested funds:

State Overhead Rate:	10
Total State Funds:	79364
Federal Overhead Rate:	48.5
Total Federal Funds:	90036

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

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

No

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

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

No

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

No

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

No

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

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)

Dr. James Carlisle	**CalEPA, Health & Eco Risk Div**	**(916) 327-2506**	**jcarlisle@oeehha.ca.gov**
Dr. Clarence Callahan	**US EPA**	**(415) 744-2314**	**callahan.clarence@epa.gov**
Dr. Julie Yamamoto	**Calif. Dept of Fish & Game**	**(916) 327-3196**	**jyamamot@ospr.dfg.ca.gov**
Dr. Steve Wong	**Calif. Dept. of Food & Ag, Feed, Fertilizer, and Livestock Drugs**	**(916) 654-0574**	**swong@cdfa.ca.gov**

21. **Comments:**

Environmental Compliance Checklist

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

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.

      No activities which have the potential to have a physical impact on the environment or the enactment of zoning ordinances, the issuance of conditional use permits, or the approval of tentative subdivision maps are associated with the proposal.

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

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

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?**

   No

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

   No

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

   The proposed study's goal is to determine if the risk based concentrations developed for fertilizers containing arsenic, cadmium, and lead, which are protective of human health, are also protective of ecological receptors. As such, it involves research only.

4. **Comments.**

   None

Conflict of Interest Checklist

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

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):

Ronald Tjeerdema, University of California, Davis

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

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

Lee R. Shull	Montogomery Watson Harza
Mark K. Jones	Montogomery Watson Harza
Carin A. Loy	Montogomery Watson Harza
Pam Fong	Montogomery Watson Harza
Mark A. Bowland	Montogomery Watson Harza

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

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

Douglas R. Christensen	**Montogomery Watson Harza**
Carmina Caselli	**UC Davis**

Ken Kiefer **Montogomery Watson Harza**

John Hunt **UC Davis/Santa Cruz**

Comments:

Budget Summary

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

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.

State Funds

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	Phase I Scoping	1067	20067	2318	1000	6000	0	2000	115276	146661.0	5438	152099.00
2	Phase I ERA	1067	20067	2318	2000	2000	0	4000	99451	129836.0	2638	132474.00
3	Phase II Scoping	1067	20067	2318	1000	4000	0	0	99349	126734.0	2738	129472.00
		3201	60201.00	6954.00	4000.00	12000.00	0.00	6000.00	314076.00	403231.00	10814.00	414045.00

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**
4	Phase II ERA	3202	61395	7091	3000	6000	0	0	312919	390405.0	7749	398154.00
		3202	61395.00	7091.00	3000.00	6000.00	0.00	0.00	312919.00	390405.00	7749.00	398154.00

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=812199.00

Comments.

Budget Justification

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

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

Principal Investigator, Ronald Tjeerdema: 174 hours/yr1, 174 hours/yr2 Specialist, Michael Singer: 418 hours/yr1, 418 hours/yr2 2 Graduate Student Research Assistants, To Be Named: (1305 hours/each)total of 2610 hours in yr1, (1305 hours/each) total of 2610 in yr2.

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

Principal Investigator, Ronald Tjeerdema: Yr1 100 %, 1 month @ $8946/mo; Yr2 100%, 1 month @ $9113/mo; Specialist, Michael Singer: Yr1 20%, 12 months @ $5936/mo; Yr2 20%, 12 months @ $6055/mo; 2 Graduate Student Research Assistants, To Be Named: Yr1 100%, 3 months @ $2438/mo & 50%, 9 months @ $2487/mo; Yr2 100%, 3 months @ $2487/mo & 50%, 9 months @ $2536/mo.

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

Principal Investigator, Ronald Tjeerdema: 8% Benefit Rate Specialist, Michael Singer: 23% Benefit Rate 2 Graduate Student Research Assistants, To Be Named: 8% Benefit Rate

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

Travel is budgeted for the purpose of annually presenting the results of this study at major international meetings, such as the Society of Environmental Toxicology and Chemistry (SETAC). The results and finsings derived from this investigation may provide assistance to others attempting to manage the ecological risks of agricultural fertilizers and their components. The cost of one trip annually would be approximately $2,000.

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

Office Supplies: $2,000 (year 1); $2,000 (year 2) Laboratory Supplies: $4,000 (year 1); $1,000 (year 2) Computing Supplies: $2,000 (year 1); $2,000 (year 2) Field Supplies: $4,000 (year 1); $1,000 (year 2) Totals: $12,000 (year 1); $6,000 (year 2)

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.

None

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.

The budget includes the purchase of three new personal computers and printers at a unit price of approximately $2,000 each. They will be used for data compilation, mathematical modeling, risk assessment, and project management.

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.

Planning and coordination of personnel: salary and benefits - $604 (year 1), $ (year 2); equipment $500 (year 1), $0 (year 2); supplies $500 (year 1), $750 (year 2). Inspection of work in progress: salary and benefits - $604 (year 1), $ (year 2); equipment $500 (year 1), $0 (year 2); supplies $500 (year 1), $750 (year 2). Report preparation: salary and benefits - $604 (year 1), $ (year 2); equipment $500 (year 1), $0 (year 2); supplies $500 (year 1), $750 (year 2). Giving presentations: salary and benefits - $604 (year 1), $ (year 2); equipment $500 (year 1), $0 (year 2); supplies $500 (year 1), $750 (year 2). Totals: salary and benefits - $2,416 (year 1), $2,460 (year 2); equipment $2,000 (year 1), $0 (year 2); supplies $2,000 (year 1), $3,000 (year 2). Note: 11/12 of the annual salary of R. S. Tjeerdema is directly paid by the university. This proposal reflects the 1/12 that would be paid by CALFED.

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

UCDs principle contractor on this project, Montgomery Watson Harza (MWH Global), possesses a professional ecological risk assessment capability lacking a UCD. The budget targeted for MWH is justified for the following reasons: 1. The professional toxicology and risk assessment staff at MWH are highly experienced in the fields of ecological risk assessment. The combined experience of the six professional staff is 54 years in risk assessment. UCD does not possess this essential expertise and experience. 2. The science and methodologies employed in a quantitative ecological risk assessment of the type proposed in this project have been developed primarily in the non-academic private (e.g., MWH) and public sectors (e.g., USEPA) over the past 7-10 years. MWH personnel in the proposed project possess a working knowledge of the essential methodologies that will be needed to successfully meet the goals of this project. 3. Success of the proposed project includes acceptance of the methods and results by regulatory agencies (e.g., Cal/EPA, USEPA, Water Quality Control Boards, US Fish and Wildlife, Cal Fish and Game), as well as other involved entities [e.g., California Department of Food and Agriculture (CDFA), California legislature, environmental groups]. MWHs risk assessment experience includes successful acceptance and approval of numerous other risk assessments by the regulatory agencies and others. 4. Three of the MWH professional toxicology and risk assessment staff proposed for this project (Shull, Jones, Bowland) performed the previously-mentioned human health risk assessment on behalf of the California Department of Food and Agriculture (CDFA), an effort that required five years (1993-1998). The carryover experience of these professionals is essential to the proposed project, not only because of their expertise in ecological risk assessment, but also because of the experience gained from the human health risk assessment of lead, cadmium and arsenic in commercial, inorganic fertilizers in California. Other resources of MWH not available at UCD, can be made available, as needed, to the project. For example, MWH has professional chemists, hydrogeologists, soil scientists, environmental, and environmental fate and transport modelers that can be consulted on an as needed basis to assist in successfully completing the project As mandated by UC Davis Policy, there is the standard graduate student fee remission cost that is applied consistently to all grants and contracts when employing graduate students. Year one is calculated at $5073/year for two students, totaling $10,146. We anticipate an increase by 5% to $5326 for two students, totaling $10,652 in year two.

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.

10% MTDC; equipment and student fees are exempt; F&A applied only to the first $25,000 of the subcontract.

Executive Summary

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

The California Department of Food and Agriculture (CDFA) regulates the effectiveness and safety of fertilizing materials essential to Californias food and fiber production. Prompted by Proposition 65 (1986), CDFA and the fertilizer industry initiated studies to address Prop-65 listed heavy metals (lead, cadmium, arsenic) present in commercial fertilizers. Since 1992, CDFA has conducted, sponsored and/or participated in studies designed to assist the Department and the industry in addressing heavy metal-related concerns. One such study, a comprehensive, state-of-the-art human health risk assessment (HRA) performed in 1992-8, resulted in development of risk-based concentrations (RBCs) of lead, cadmium and arsenic in phosphate and micro-nutrient fertilizers. Regulatory enforceable standards for the three subject metals will be based on these RBCs (Exhibit B). During the HRA peer review and facilitated rule-making process, various sectors questioned the ecological and ecosystem protectiveness of the HRA-based RBCs, including questions about the contribution of fertilizer application to metal concentrations in Californias waters and sediments and potential impacts on ecosystems. Whereas the overall goal of the proposed study is to improve the environmental friendliness of Californias valuable agricultural industry, a specific goal is to directly assess the ecological and ecosystem protectiveness of the lead, cadmium and arsenic RBCs. The proposed two-year study is a three-leveled, quantitative ecological risk assessment (ERA) performed by the team of U.C. Davis and Montgomery Watson Harza. The RBCs will be input concentrations to a state-of-the-art terrestrial and aquatic ecosystem model. Cal/EPA and USEPA ERA guidance will be followed. The three levels of ecological management zones are (1) local level (hypothetical farm), (2) intra-valley regional level (San Joaquin Valley, Sacramento Valley), and (3) inter-valley-wide level. The study results will not only directly assist CALFED in meeting its stated ecosystem restoration objectives, it will also directly benefit the long-range environmental objectives of CDFA and Californias agricultural industry.

Proposal

University of California, Davis

Ecological Risk Assessment for Heavy Metals in Commercial, Inorganic Fertilizer

Ronald Tjeerdema, University of California, Davis

ECOLOGICAL RISK ASSESSMENT FOR HEAVY METALS IN COMMERCIAL, INORGANIC FERTILIZER

ECOSYSTEM RESTORATION PROGRAM 2002 PROPOSAL SOLICITATION

Prepared for

October 5, 2001

Submitted by

UCDAVIS

Ronald S. Tjeerdema, PhD, DABT
Professor, Department of Environmental Toxicology
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CONTENTS

ECOLOGICAL RISK ASSESSMENT FOR HEAVY METALS IN COMMERCIAL, INORGANIC FERTILIZER

ECOSYSTEM RESTORATION PROGRAM 2002 PROPOSAL SOLICITATION

A. PROJECT DESCRIPTION: PROJECT GOALS AND SCOPE OF WORK

The overall goal of the proposed study is to improve the environmentally friendliness of California's valuable agricultural industry. A more specific goal is to determine if recently-developed human health based risk based concentrations (RBCs) for arsenic, cadmium and lead that exist in commercial fertilizers applied to California's farmlands, are also protective of ecological receptors and their ecosystems. The study will be performed over two years and be conducted in two phases. Key tasks included in the scope of work are detailed in Attachment A. Details of the problem and the approach are provided below.

1. Problem

Agriculture is foundational to California's past, present and future. California leads the nation in the production of many commodities including wine grapes, walnuts, and artichokes. Because of California's high-quality soils, temperate climate, and access to irrigation water, the state's growers and workers are able to produce over 250 different food, fiber, and livestock commodities. One of the major principles of the state's environmental and agricultural policy is to sustain the long-term productivity of the state's agriculture by conserving and protecting the soil, water, and air that are agriculture's basic resources.

Diversion of irrigation water from the rivers and Delta during this century has positively affected agricultural productivity, but has also led to water and sediment quality concerns. The application of fertilizers and pesticides on 500,000 acres of Delta farmland and another 4.5 million acres in the San Joaquin and Sacramento Valleys has adversely affected the beneficial uses of water for drinking, fishery resources, recreation, and agricultural uses, as well as substantially altering adjacent and proximate terrestrial and riparian habitats.

The Agricultural Commodities and Regulatory Services (ACRS) Branch of the California Department of Food and Agriculture (CDFA), regulates the distribution of effective and safe fertilizing materials essential for California food and fiber production. In 1993, prompted by California's Proposition 65, CDFA working in conjunction with the fertilizer industry initiated studies to address the subject of heavy metals in commercial fertilizers. Three Proposition 65-listed heavy metals (lead, cadmium, arsenic) have been the primary focus of these activities, including (1) a chemical analysis survey of concentrations in commercial fertilizer products in California, (2) field research to determine loading rates of these metals in California soils resulting from long-term fertilizer application, and (3) a comprehensive, multi-phased human health risk assessment (HRA). Various parts of this overall research effort have been funded by

the Fertilizer Research and Education Program (FREP), which derives from a mill tax on fertilizer products sold in California. ACRS formed a Heavy Metals Task Force to oversee the various heavy metal activities of the Department including the HRA. The three-phased HRA effort included (1) a feasibility study, (2) a baseline deterministic HRA based on heavy metal content measured by CDFA in California fertilizers, and (3) a probabilistic HRA from which human-health protective risk-based concentrations (RBCs) of lead, cadmium and arsenic in phosphate and micronutrient fertilizers.

The HRA study, which was performed by members of the project team in this proposal (Shull, Jones, Bowland) was completed in July 1997, and was peer reviewed by a panel of scientists affiliated with academia, the fertilizer industry, and both state (e.g., Cal/EPA, University of California) and federal (e.g., USEPA, USDA) governments. The HRA results were published in March 1998 in a CDFA report entitled "Development of Risk-Based Concentrations for Arsenic, Cadmium, and Lead in Inorganic Commercial Fertilizers." Following the release of the above report, CDFA initiated a process to adopt regulatory standards for arsenic, cadmium and lead in fertilizers. This process utilized a facilitated rule-making approach where representatives from industry, legislative, state and local agencies, and special interest groups (e.g., environmental groups) reviewed available information and provided input into the development of proposed regulatory standards. Regulations were proposed in August 1999. The regulations were finalized and filed with the Office of Administrative Law on September 6, 2001 (Title 3, CCR Sections 2302 and 2303, in progress); a copy of the proposed regulations is provided in Attachment B.

The primary goal of the RBC development process, and resultant proposed regulations, was the protection of human health, including minimizing the impacts of fertilizer application on drinking water quality. During the peer review of the risk assessment, facilitated rule-making process and adoption of regulations, various questions were raised regarding the protectiveness of the RBCs against adverse ecological and ecosystems impacts. To address this concern, the CDFA initiated a study on "The Role of Inorganic Chemical Fertilizers and Soil Amendments on Trace Element Contents of Cropland Soils in California." However, while this study will provide valuable information on the fate of metals in cropland soils, it will not assess the potential impacts of the subject metals on terrestrial and aquatic receptors or associated ecosystems, nor does it address Bay-Delta water quality.

2. Justification

The proposed law promulgating the RBCs is expected to sunset in 2006, at which time there will be an opportunity to revise the RBCs, if needed. The intent of the proposed study is to fill a significant data gap in the proposed regulations and evaluate whether the RBCs, which are human-health based, are also protective of terrestrial and aquatic ecosystems, and Bay-Delta water quality.

The project will study the potential ecological impacts of the three principle heavy metal impurities found in commercial inorganic fertilizers; lead, cadmium and arsenic. In addition to characterizing effects on biota, the spatial and temporal extent of heavy metal impacts from fertilizer use on the Bay-Delta will be estimated. To these ends, the study will evaluate interconnections between heavy metals, wide-spread environmental disposition in fertilizers, post-application runoff, potential for accumulation in ecologically sensitive areas (e.g.,

Sacramento and San Joaquin river sediments), potential impacts on habitat and/or food webs, and other potential negative impacts (either loss of habitat, loss of food supply, or direct toxicity).

The study approach consists of a three-phased ecological risk assessment (ERA) using the established RBCs as input concentrations into a state-of-the-art terrestrial and aquatic ecosystem model. A conceptual model for the study is presented in Figure 1. Phase I of the ERA will be a Scoping Assessment, consistent with standard regulatory ERA guidance, to evaluate whether the established RBCs could impact terrestrial and aquatic ecosystems on a local level, where 'local' is defined as an individual farm or ecological management zone. Phase II of the study will estimate potential impacts of the established RBCs on terrestrial and aquatic ecosystems at the regional level, where 'regional' is defined the collection of CALFED ecological zones within the San Joaquin Valley or the Sacramento Valley. Phase III of the study, which is planned for a subsequent proposal submittal, will build on the results of the Phase II study to evaluate the potential impacts of the established RBCs on terrestrial and aquatic ecosystems in the Bay-Delta, as well as on Bay-Delta water quality. Only Phases I and II are included in the current proposal submittal.

The study fundamentally supports the CALFED Bay-Delta Ecosystem Restoration Program (ERP) objectives in that it will quantitatively evaluate whether regulations specific to heavy metals in commercial, inorganic fertilizers that are applied on millions of acres of soil in California impact terrestrial and aquatic ecosystems, specifically Bay-Delta water and sediment quality. Because these regulations will be re-evaluated in five years, results of the proposed study can be used to determine whether revision of the regulatory metals standards is warranted.

The study will further contribute to the following CALFED science program goals by adding to the body of knowledge for:

- *Advance process understanding*. Because of the extensive fate and transport modeling in the proposed study, scientific understanding of relevant physical, biogeochemical, and ecological processes, as they relate to agricultural practices, will be advanced and can be applied in ecosystem restoration programs.

- *Advance the scientific basis of regulatory activities*. Because the study is being performed in response to recent regulations that will be re-evaluated in five years, better science will be available as a result of this study, especially for (1) managing water and protecting at-risk species; (2) critically re-evaluating and potentially revising the regulations, if warranted, and (3) ensuring the protection of terrestrial and aquatic ecosystems and Bay-Delta water and sediment quality. The study will also help in addressing uncertainties in the science used for management of the CALFED Science Program.

- *Wildlife-friendly agriculture incentive program.* Because the study is tied to regulations concerning concentrations of heavy metals in commercial, inorganic fertilizers and will be used as a basis for re-evaluating the regulations in five years, it will necessarily support development and implementation of farming methods and crops that are favorable to wildlife.

- *Compare effectiveness of different practices*. Because a wide-range of different agricultural practices and areas will be assessed in the study, it will help improve knowledge of the relative effectiveness of different wildlife-friendly agricultural practices. In addition, in potential subsequent phases of the study, it can aid in systematic comparisons of existing projects or designing multiple projects as systematic adaptive management experiments.

Thus, results of the study will both improve fertilizer regulation and contribute to the basic understanding of metal transport throughout the Central Valley and Bay-Delta ecosystems.

3. Project Approach

The proposed ERA will provide a framework for predicting potential adverse effects of arsenic, cadmium, and lead (the metals of interest [MOIs]) on biota located on or down-gradient (e.g., downstream, down wind) of a single fertilizer application site or larger regions of fertilizer application. The ERA will benefit from the five-year effort that went into the HRA (CDFA, 1998) in several ways:

- Specific information on virtually all fertilizer products applied in California (45 individual products were evaluated in the HRA), six crop categories, and multiple fertilizer application scenarios, and categories of California soil to which fertilizers are applied. Relevant information for each of these items will be used directly in the proposed ERA.

- The results of fate and transport modeling analyses including fugitive dust generation and dispersion, surface runoff into surface water bodies, accumulation in soil of heavy metals from applied fertilizers, and transfers into agricultural products (*i.e.*, produce, beef, milk). Relevant inter-media transfer relationships from these analyses will be used in the proposed ERA.

- The HRA-derived RBCs for the three MOIs will be used as the input concentrations in the proposed ERA, which assumes that the concentrations of the metals in applied fertilizers do not exceed the RBCs as defined in the regulations.

The proposed ERA will be implemented using a phased approach and at two geographic levels: (1) a local level and (2) a regional level. In Phase I, an ecological management zone in the Sacramento Valley will be selected for analysis as a 'test zone.' For this test zone, a Scoping Assessment will be performed at both the single farm and the ecological management zone levels in order to develop a conceptual model of potential receptors and potentially complete exposure pathways. Subsequently, a probabilistic ERA will be performed to (1) quantify the potential MOI exposure levels, if any, received by terrestrial and aquatic ecological receptors, and (2) estimate the toxicological impact to indicator species posed by the predicted exposure levels.

In Phase II, a Scoping Assessment and Phase I predictive ERA will be performed for each of the additional ecological management zones in the Sacramento and San Joaquin valleys using the processes developed for the test zone. These probabilistic predictive assessment results will then be synthesized to study RBC potential hazards at a third geographic scale; the Sacramento Valley and the San Joaquin Valley. It is expected that this information will ultimately be incorporated

into a valley-wide assessment of long-term fertilizer application containing the MOIs on the Bay-Delta ecosystem (Phase III).

3.1 Approach for the Scoping Assessment

The purpose of the Scoping Assessment is to develop a conceptual model that describes the potential for contact between ecological receptors and fertilizer-related MOIs applied on a farm or collection of farms. The Scoping Assessment will use:

- Fate and transport modeling to predict potentially complete exposure pathways between the fertilizer application site(s) and biological receptors. (Section 3.3)

- Literature sources, such as the California Department of Fish and Game's *California Wildlife Habitat Relationships Database*, to identify potential ecological receptors that may come in contact with fertilizer related arsenic, cadmium and lead. Highest priority will be given to species formally listed under the Federal and California Endangered Species Acts (ESAs)

Some of the variables that will be considered when developing the conceptual model include:

- *Crop type*. Consistent with the development of the RBCs, the ecological Scoping Assessment will address fertilizer application on single crop farms (vegetables, roots, vines, grains, fruit trees); forage crop farms (for example, dairy farms and cattle ranches); and multi-crop farms (for example, grow all crop types, including animal forage, simultaneously). Application of commercial fertilizer on rice farms will also be specifically evaluated in the ecological Scoping Assessment.

- *Fate and transport characteristics of chemicals*. Mathematical modeling will be used to estimate the distance arsenic, cadmium and lead at the RBC can migrate away from an individual farm or collection of farms through soil, surface water, groundwater and air. This modeling is discussed in further detail in Section 3.3.

- *Ecological management zones*. The acreage within a particular ecological management zone devoted to a particular crop type and fertilizer application routine will be estimated. The potential for special status species (e.g., endangered species) to reside within the influence of a particular farm or collection of farms will be determined.

Assessing MOIs applied in fertilizers to multiple crops within an ecological management zone includes assessing the potential for the MOIs to be transported outside the ecological management zone. If such potential is determined, additional potentially-affected ecological resources will be identified, incorporated into the conceptual model, and assessed in the Phase I ERA.

3.2 Approach for the Probabilistic Ecological Risk Assessments

Based on the results of the Scoping Assessments, probabilistic predictive ecological assessments will be conducted. The procedures to be used for these assessments will be consistent with those described in state and federal guidance of the Cal/EPA (Cal/EPA, 1996a,b) and the USEPA,

(USEPA, 1997, 1998, 1989a, 1989b, 1992, and 1994.). Details of the probabilistic ERA approach follow.

Problem Formulation

The problem formulation step (USEPA, 1992) includes information on the following: (1) identification of chemicals of potential ecological concern; (2) descriptions of the biological resources present or potentially present; (3) identification of indicator receptors for evaluating the assessment and measurement endpoints and (4) the assessment and measurement endpoints selected for the study.

Chemicals of Potential Ecological Concern. For this study, the chemicals of potential ecological concern are the MOIs.

Biological Resources. A description of the biological resources potentially affected by fertilizer-applied MOIs will be generated by the Scoping Assessment.

Indicator Receptors. Since it is not possible to evaluate potential impacts to all receptors inhabiting the potentially affected ecosystems, it will be necessary to identify indicator species for study in the quantitative ERA. Information that will be considered in the selection of indicator species includes:

- The nature of the food webs and food guilds occurring or potentially occurring on-farm and/or off-farm within an ecological management zone;
- Species sensitivity to the MOIs;
- Availability of toxicity information or benchmark criteria
- Status as a 'threatened and endangered' or 'special status' species.
- Commercial or game value.

Following the selection of representative species, representative food web(s) will be developed to establish relevant predator-prey relationships among the various species and to incorporate how the MOIs might be transported through the identified food web.

Assessment and Measurement Endpoints. As defined in USEPA's *Guidelines for Ecological Risk Assessment* (USEPA, 1998), an assessment endpoint is an explicit expression of the environmental value that is to be protected. An assessment endpoint is usually broad in its description and is not easily quantified. For example, "protection of animal populations from adverse affects on their growth and reproduction" is an assessment endpoint and could be assessed in multiple non-quantitative ways, including simply whether or not certain species are present. In contrast, a measurement endpoint is defined as a measurable response to a stressor that can be related to the ecological characteristic(s) chosen as the assessment endpoint (USEPA, 1998). For example, during a flood, plant growth can be measured and related to an amount of water received. In this case, water is the stressor and the plant height is the measurement endpoint.

The stressors in the proposed ERA are the MOIs introduced into the environment by the practice of fertilizer application to cropland. The assessment endpoint is the protection of on-farm and off-farm plant, bird and mammal populations and protected individuals from the subsequent adverse effects of MOIs resulting from long-term fertilizer application. To select measurement endpoints, a literature search will be performed to identify adverse chemical affects of MOIs on the representative species selected for the assessment, including but not limited to survival, growth, and reproductive effects. These measurement endpoints will be used in the 'effects assessment' (see below).

Exposure Assessment

The purpose of the exposure assessment phase of the probabilistic ERA is to describe and quantify (when appropriate) the potential co-occurrence of representative receptors and MOIs. Potential exposure will be evaluated by estimating MOI exposure point concentrations in abiotic and biotic media, and subsequent uptake by indicator receptors through mathematical modeling. Estimated soil exposure point concentrations will reflect the application rate and frequency of the fertilizer to the farm(s). Estimated receptor doses will reflect the life history of the indicator receptors. (How much of the MOI does the receptor ingest, inhale, and/or dermally absorb per day?) The results of the exposure assessment will be considered in relation to the results of the toxicity assessment to characterize ecological risk.

Effects Assessment

The potential for ecological effects due to exposures of indicator receptors to MOIs will be evaluated by comparing calculated exposure levels with toxicity reference values (TRVs) for each MOI-receptor combination. TRVs are dosages used in controlled laboratory studies and published in the literature. probabilistic ecological risk assessment will establish probability density functions (PDFs) for each of the TRVs developed in the study. Therefore, the development of TRV PDFs is a critical element of the ERA and will provide a significant scientific advancement in the understanding of the toxicology of the subject MOIs on terrestrial and aquatic species. Multiple toxicity benchmarks will be derived from the literature search performed to identify measurement endpoints. In general, TRVs that represent chemical dosages that would not adversely effect a species' population will be selected; however, when protection of endangered species is an issue, other systematic or behavioral endpoints will be considered on a case-by-case basis. In addition, whenever possible, TRVs specific to an indicator receptor will be incorporated into the ERA. In cases where benchmarks are not available for a given indicator receptor, toxicity benchmarks provided for a test species will be allometrically converted to a toxicity reference value for each indicator species.

Risk Characterization

The ecological risk characterization will combine all the gathered information to determine the potential ecological risk that may result as a result of fertilizer application for each of the three levels: the individual farm level; the ecological management zone level and the valley-wide level. For each level, if a modeled exposure (dosage) is found to be less than the literature-derived acceptable dosage for each representative receptor, then the RBC will be considered protective. A modeled dosage greater than a literature-derived dosage is an indication that an

RBC may not be protective of one or more ecological receptors, and that additional study, or a change in agricultural practice, or perhaps a revision of an RBC is warranted.

3.3 Fate and Transport Modeling

In the Scoping Assessment, fate and transport modeling will be used in order to narrow the ecological receptor search to a reasonable list of habitats that could be affected by MOIs applied in fertilizers. In the probabilistic predictive ERA, fate and transport modeling will be used to calculate the expected range of MOI concentrations in down gradient media and hence, exposure point concentrations (dosages) to representative receptors.

The Phase II fate and transport water quality modeling will necessarily be sophisticated, but will be designed to be flexible in order to support analysis of a variety of scales. It will involve complex, interrelated watershed modeling. Watershed modeling will be consistent with other CALFED approaches and can be estimated using a variety of rain-fall runoff methods including such methods as a rational method, unit hydrograph method, storage routing models, network models, an SCS method, etc. Choice and validity of runoff methods depend on watershed characteristics, data availability, and runoff processes that are likely to be dominant.

The fate and transport modeling will use an integrated approach with emphasis on accessing readily available watershed and environmental data. A review of currently available models (e.g., USEPA's BASINS system or available CALFED sponsored models) will be undertaken to determine applicability to the goals of the study. The modeling approach will also use a geographic information system (GIS) for the model framework. GIS provides a framework for the modeling that will allow for the analysis of watershed and water quality relationships at varying scales.

4. Feasibility

The proposed study is a logical, and critical, continuation of previous HRA study on the agricultural use of inorganic, commercial fertilizers in California, and the risks associated with levels of arsenic, cadmium, and lead in these products. Because the HRA, which was a five-year effort, has already been conducted, much of the foundational information needed for the proposed ERA study is already available. The successful completion of the HRA demonstrates the qualifications and commitment that the research team has for the proposed study.

Not withstanding the success of the HRA, there are many additional challenges presented by the proposed study. Some of the more significant challenges are the scale of study (both conceptually and spatially), scientific challenges (e.g., development of TRV PDFs), and fate and transport modeling approach (e.g., the varying scale from simple local surface water modeling to more complex regional modeling). However, similar to the HRA, a phased approach is planned for the proposed ERA, which allows for the performance of the work in manageable and feasible components.

In addition, there are no serious time constraints for the study; completion of the study within two to three years is a reasonable expectation. Also, the study not constrained by any special requirements (e.g., no field studies are proposed, no special agreements or permits will be necessary). Although an ambitious undertaking, the phased approach of breaking the study into

manageable units, the availability of necessary resources at both UC Davis and Montgomery Watson Harza (MWH) including professional staff with extensive and relevant experience (e.g., the same staff that worked on the HRA for five years, toxicology expertise, modeling expertise, applicable modeling software programs), successful completion of the proposed study within a reasonable time-frame is an achievable goal.

5. Performance Measures

Project performance will be monitored by both qualitative and quantitative criteria. The quantitative measures will compare actual project progress and results to an initial project plan. This plan, which will include task plans, schedule, budget, deliverable milestones and project performance measures, will be prepared at the beginning of the project in consultation with CALFED staff. Budgets will be assigned to each task. The project monitoring results will be summarized in quarterly progress reports. The quarterly progress reports will be submitted to CALFED, and will include the following minimal information: (1) individual task progress to date versus plan, (2) overall project schedule verses plan, and (3) project budget spent compared to plan budget. These quarterly reports will also identify and describe corrective actions needed when the negative variances to the project plan occur in order return the project to plan as quickly as possible. A schedule for the proposed study is presented in Section 8.

6. Data Handling and Storage

A data management plan will be developed for the study that will include procedures for receiving data include receipt of electron data, and entry and filing of original hardcopy. Data storage includes merging entered data into a computer database, verification of entered data, and backup procedures for electronic and hardcopy data. All data will be entered into a Microsoft Access computer database. Data will be entered into the database manually or by direct upload of obtained electronic data. Regardless of the method of data entry, data entry quality control will be maintained through several types of data checking. Data checking will be carried out prior to merging the temporary input file with the master database file. Following correction of any inconsistencies in the data file, the temporary input file will then be merged to a proxy master file. This proxy file will be used as a daily working file, and backups of it as well as the master file will be maintained. Following data entry, the data will be stored in a computer database management system. The database will include fertilizer application data, soil properties data, exposure data, toxicity data, and fate and transport modeling data

Data management will be integrally connected with GIS. GIS uses computer technology for managing, manipulating, analyzing, and presenting geographic spatial data. Thus, GIS allows tabular data to be referenced to geographic features. Use of GIS allows for data input, data storage, retrieval, and query, and data analysis and modeling, including spatial statistics. GIS also allow quick and easy retrieval of relevant information. GIS provides the tools to pull together all the data, to make routine and critical management decisions and to dynamically present complex and technical information. Because data incorporated in GIS is in the form of layers or ‘themes,’ it allow for a very flexible and interactive means for data analysis, data integration, data correlation, and data presentation, all at varying spatial scales.

7. Expected Products/Outcomes

The study is expected to answer the primary question, which is: are the regulatory RBCs for lead, cadmium and arsenic in commercial, inorganic fertilizers protective of terrestrial and aquatic ecosystems, and Bay-Delta water and sediment quality? In addition to answering this basic question, a number of other outcomes will be forthcoming:

- If the regulatory RBCs are not protective of terrestrial and aquatic ecosystems, and Bay-Delta water and sediment quality, to what extent will the regulations need to be modified to ensure the protection of terrestrial and aquatic ecosystems and Bay-Delta water and sediment quality.

- Methods and models for addressing other separate, but related, potential sources of impact on California ecosystems will be developed (e.g., land disposal of municipal biosolids).

- Methods and models for addressing other metals (e.g., copper, chromium) in fertilizers in future similar studies.

- Identification of drivers and data gaps that can guide future research on the subject of metals in fertilizers and there potential impacts on terrestrial and aquatic ecosystems and Bay-Delta water and sediment quality.

- A basis for modifying agricultural practices for reducing metal impacts on water and sediment quality.

- Feedback to the fertilizer industry on safe heavy metal levels in products that are protective of ecosystems and/or specific ecological receptors (e.g., endangered species).

- Because the study will be conducted probabilistically, a sensitivity analysis will be performed, which will provide a quantitative identification of factors that have the greatest associated influence and uncertainty. Once identified, future research can be considered for expanding the knowledge base for these factors.

- Providing the necessary input information and resources for conducting Phase III of the study, which is the evaluation of impacts of established RBCs on terrestrial and aquatic ecosystems in the Bay-Delta, and Bay-Delta water and sediment quality on a valley-wide basis.

The phased approach will generate a number of 'products' during the course of the study. The *first product* will be the results of the Phase I Scoping Assessment and development of a comprehensive conceptual model. The *second product* will be the results of the local ecological risk assessment, including the development of fate and transport modeling on an ecological management zone level. The *third product* will be the results of the ERA. An important element of the third product is the development of a regional fate and transporting modeling approach. Additional products will be multiple publications in peer-reviewed scientific journals (e.g., the various TRV PDFs), which will contribute to various scientific fields including ecological risk assessment, ecotoxicology, and fate and transport modeling.

8. Work Schedule

The proposed study can be initiated immediately following CALFED approval. Each task is dependent on the results of and data obtained from subsequent task(s). For example, in order for the Phase II scoping assessment to be performed, both the Phase I scoping assessment and the Phase I predictive ERA must first be completed. This could lead to the potential for incremental funding for each sequential task of the study. Figure 6 presents the anticipated schedule for each task of the study, including expected start and stop dates, and accomplishment of major milestones.

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

1. ERP, Science Program and CVPIA Priorities

The proposed study directly and fundamentally addresses the draft Stage 1 PSP priority MR-2 (*Develop programs for Wildlife-Friendly Agriculture and conduct studies to better understand relationships between farming and wildlife habitat*). The goal and primary focus of the study is to evaluate whether regulations recently established for acceptable levels of arsenic, cadmium, and lead in commercial, inorganic fertilizers used in California agriculture are protective of valuable ecosystems and associated ecological receptors.

Specific issues addressed within the MR-2 priority are: (1) the wildlife-friendly agriculture incentive program, and (2) comparison of the effectiveness of different agricultural practices. Contributions to each of these issues by the study are detailed below:

- *Wildlife-friendly agriculture incentive program.* Because the study is linked to regulations concerning concentrations of heavy metals in commercial, inorganic fertilizers, and will be used as a basis for re-evaluating the subject regulations in 2006, it will necessarily support an incentive program for implementing farming practices that are favorable to wildlife.

- *Compare effectiveness of different practices*. Because a wide-range of different agricultural practices and geographic areas will be assessed in the study, it will help improve knowledge of the relative effectiveness of different wildlife-friendly agricultural practices. In addition, in potential subsequent phases of the study, the results will aid in systematic comparisons of existing projects or designing multiple projects as systematic adaptive management experiments.

The proposed study also directly addresses the draft Stage 1 PSP priority MR-5 (*Ensure that restoration is not threatened by degraded environmental water quality.*). Specific issues addressed within the MR-5 priority are: other pollutants, and pollutant effects. Contributions to each of these issues by the proposed study are:

- *Other pollutants.* The proposed ERA will provide a framework for predicting potential adverse effects of arsenic, cadmium, and lead on ecological receptors in terrestrial and aquatic ecosystems, as a result of commercial, inorganic fertilizer in California agriculture. The potential adverse effects to be evaluated by the study include potential impacts on habitat

and/or food webs, and other potential negative impacts (either loss of habitat, loss of food supply, or direct toxicity).

- *Pollutant effects*. An integral part of the proposed study will be evaluating the potential for ecological effects due to exposures of representative ecological receptors to arsenic, cadmium, and lead. The development of probabilistic toxicity reference values (TRVs) is a critical element of the ERA and will provide a significant scientific advancement in the understanding of the toxicology on terrestrial and aquatic ecosystems for these heavy metals.

In addition, the study will further contribute to the following CALFED science program goals by adding to the body of knowledge in the following ways:

- *Advance process understanding*. Because of the extensive fate and transport modeling in the proposed study, scientific understanding of relevant physical, biogeochemical, and ecological processes as they relate to agricultural practices will be advanced and can be used to evaluate implications for restoration.

- *Advance the scientific basis of regulatory activities*. Because the study is being performed in response to recent regulations that will be re-evaluated in five years, better science will be available as a result of this study, especially for (1) managing water and protecting at-risk species; (2) critically re-evaluating the regulations and adapting the regulations, and if necessary, (3) ensuring the protection of terrestrial and aquatic ecosystems and Bay-Delta water and sediment quality. The study will also help in addressing uncertainties in the science used for management of the CALFED Science Program.

2. Relationship to Other Ecosystem Restoration Projects

Ron Tjeerdema's research group in the UC Davis Department of Environmental Toxicology is involved in a number of environmental assessment projects in the San Francisco Bay, Delta, and associated watersheds. His group is conducting water and sediment toxicity testing and pesticide measurement for the State Water Resources Control Board's Surface Water Ambient Monitoring Program in Central Valley and San Francisco Bay Region watersheds. They are responsible for a five year assessment of the causes, sources, and ecological implications of sediment toxicity in the San Francisco Bay, sponsored by the San Francisco Estuary Institute, and have participated in their Regional Monitoring Program for the past nine years. They are also involved in biological assessments and pesticide measurements for the San Joaquin River TMDL effort sponsored by the Central Valley Regional Water Quality Control Board. They are current co-authors of two proposals to CALFED: Investigation of the causes of ambient water and sediment toxicity in the Napa River, and Investigations of Toxicity of Unknown Cause in the Bay-Delta and Tributary Watersheds. Past relevant major projects include the Bay Protection and Toxic Cleanup Program, EPA EMAP and NOAA Status and Trends programs in San Francisco Bay. All of these projects are directly and indirectly inter-related to the proposed study in that they all are assessments on the ecological impacts associated with different contaminants at varying spatial scales.

3. Request for Next-Phase Funding

Not applicable, this proposal is for first-phase funding.

4. Previous Recipients of CALFED CVPIA Funding

No previous funding from CALFED CVPIA has been received by the principal investigator, Ron Tjeerdema.

5. System-Wide Ecosystem Benefits

As stated above, the application of fertilizers and pesticides on 500,000 acres of Delta farmland and another 4.5 million acres in the San Joaquin and Sacramento Valleys has adversely affected the beneficial uses of water for drinking, fishery resources, recreation, and agricultural uses, as well as substantially altering adjacent and proximate terrestrial and riparian habitats.

There are multitudes of anthropogenic metal sources to the Central Valley's riverine and delta systems, with fertilizer being just one of them. A systematic way of addressing these contributions has not yet been attempted and this study would provide a launching point for studies of other source impacts. More importantly, regulation of fertilizer in California will be improved if it is also protective of ecological receptors.

C. QUALIFICATIONS

1. Project Team, Management Approach, and Roles and Responsibilities

The project will be managed by UC Davis. Montgomery Watson Harza (MWH), an environmental consulting firm, will provide specialized capabilities in a subcontractor role. Dr. Ronald Tjeerdema, professor in the Department of Environmental Toxicology will be the Principal Investigator.

The primary project team will consist of faculty and staff from UC Davis' Department of Environmental Toxicology and professional staff from MWH. UC Davis will contribute at least three members to the study team. Some of these members will be graduate level students, who have not yet been assigned. Dr. Tjeerdeema has over 14 years of research and teaching experience in environmental toxicology, including aquatic toxicology. The graduate students to be assigned to the project will be based in one or more of the following UC Davis graduate groups: pharmacology and toxicology, agricultural and environmental chemistry, or ecology. Resources of the University of California (*e.g.*, libraries, Department of Environmental Toxicology documentation Center) are available to the project.

MWH will contribute four members to the study team: Dr. Lee Shull (former professor in the Environmental Toxicology Department at UC Davis, and Toxicology and Risk Assessment Practice Director at MWH), Mr. Mark Jones (senior toxicologist and risk assessor, GIS specialist), Mr. Mark Bowland (senior environmental toxicologist and risk assessor) and Ms. Carin Loy (senior ecologist and risk assessor). Dr. Shull, Mr. Jones and Mr. Bowland were all

primary authors of the CDFA HRA study (*Derivation of Risk-Based Concentrations of Lead, Cadmium and Arsenic in Commercial Fertilizer; California Department of Food and Agriculture, 1998*), which derived the RBCs for of arsenic, cadmium and lead in commercial, inorganic fertilizers in California.

The roles and responsibilities for both UC Davis and MWH in the project are:

UC Davis:

- *Primary role*: Overall project management, including direct reporting to CALFED.
- *Primary role*: Development of scientific reports.
- *Primary role*: Development of toxicity reference values (TRVs): evaluation of existing TRVs for applicability to the project, toxicology literature search and review, selection and evaluation of appropriate toxicology studies, development of TRVs, development of probability density functions (PDFs) for specific TRVs, if warranted.
- *Secondary role*: identifying potentially impacted ecological receptors, and selecting indicator species.
- *Secondary role*: environmental fate and transport modeling (*e.g.*, selection of appropriate parameters and factors, selection of appropriate modeling approaches).

MWH:

- *Primary role*: all aspects of the ecological risk assessment (*e.g.*, scoping, developing appropriate technical approaches for each phase, identifying potentially impacted ecological receptors and indicator species, developing equations, fate and transport modeling, ecosystem modeling, performing risk calculations).
- *Secondary role*: support project management and other primary roles and responsibilities performed by UC Davis.

Qualifications of primary individuals follow.

2. UC Davis

Ronald S. Tjeerdema, PhD, DABT, UC Davis: Dr. Tjeerdema is a Professor in the Department of Environmental Toxicology and an Environmental Chemist in the Agricultural Experiment Station, both at UC Davis. He holds a PhD in Pharmacology and Toxicology (with an emphasis in environmental toxicology), also from UC Davis, and is Certified in General Toxicology by the American Board of Toxicology. Prior to his current appointment, he spent 12 years on the faculty of the Department of Chemistry and Biochemistry, UC Santa Cruz. In his 15-year career he has published over 100 peer-reviewed papers, and is recognized internationally as an expert in the areas of aquatic toxicology and environmental fate. Areas of particular interest include the metabolic fate of pesticides and petroleum hydrocarbons in fishes and invertebrates, the toxic actions of oil spills, effluents, and contaminated sediments in sensitive early life stages, the environmental fate of planktonic toxins, and the biochemical mechanisms of pesticides in mollusks. He currently directs a team of nearly two dozen researchers. Among his many professional activities he serves on the UC Water Resources Center Coordinating Board, as Chair of the Subcommittee on Water Quality, and on the Scientific Advisory Committee of the Oiled Wildlife Care Network. He also serves as an advisor to a number of state and federal

resource agencies, where he advises on the toxic actions and ecological risk of pesticides, petroleum hydrocarbons, and trace metals. In 1997 he served as a Co-Chair of the Annual Society of Environmental Toxicology and Chemistry (SETAC) Meeting in San Francisco.

Michael M. Singer, MS, UC Davis: Mr. Singer is a Research Specialist in the Department of Environmental Toxicology, UC Davis. He holds an MS in Marine Sciences from the CSU Moss Landing Marine Laboratories. He has extensive experience in aquatic toxicology, and has published nearly 50 peer-reviewed papers in the last 12 years. Considered an expert in aquatic toxicology, he has particular expertise in the area of aquatic toxicity testing, particularly with the sensitive early life stages of both plants and animals. He has been instrumental in driving the petroleum toxicity community towards standardized testing, and was the first to develop closed, declining-exposure testing methods.

3. MWH

Lee R. Shull PhD, MWH. Dr. Shull has over 26 years of professional experience in the field of toxicology, both as a professor at two major Universities (Michigan State University, and UC Davis, and as a toxicology and risk assessment consultant. Dr. Shull was the principal investigator for the CDFA HRA from which the RBCs were developed. As a professional consultant, Dr. Shull has provided professional service in both the public and private sectors including over 70 risk assessments (human and ecological) on numerous settings and hazardous substances associated with agricultural, residential, workplace and other environments. Also, he has served as toxicology advisor to major corporations, provided expert testimony in litigations and public hearings and guided clients in the implementation of programs for compliance with state and federal laws and regulations involving toxic substances. His 14-year academic research experience was multi-faceted and dealt with a wide variety of toxicants and biological species in the two sub-disciplines of biochemical and environmental toxicology. As a tenured professor, he authored and co-authored over 40 original research publications, several invited reviews and textbook chapters and a toxicology textbook. He has participated in numerous public meetings on public health issues and has been an invited speaker at numerous scientific symposia and conferences on a wide range of topics related to toxicology and risk assessment throughout his career. Currently, he is a Principal and Corporate/Global Practice Director of Toxicology & Risk Assessment at MWH, and is based in Sacramento, California.

Mark K. Jones, MS, MWH. Mr. Jones has over 14 years of experience in the environmental field. He provides toxicological and risk analyses on behalf of both governmental and private clients. He specializes in human health and ecological risk assessments, exposure assessment, toxicological research, risk-based cleanup level development, and Geographical Information Systems (GIS) development and analysis. Mr. Jones served as the project manager for the previous CDFA human health risk assessment. He has a thorough knowledge of federal regulations and methodologies as well as various state regulations. He has provided technical and support work for USEPA, and has managed risk assessments and GIS projects for several government and private-client facilities throughout the United States. As Senior Scientist and GIS Analyst in the Toxicology & Risk Assessment Program in MWH's, Mr. Jones provides risk assessment project management, GIS development and analysis, and data evaluation services, and is also based in MWH's Sacramento office.

Mark A. Bowland, BS, MWH. Mr. Bowland has over eight years of risk assessment and toxicology experience, including an integral role in the previous CDFA human health risk assessment. He was responsible for a bulk of the risk calculation development. Mr. Bowland is an expert in probabilistic risk analyses and has provided risk assessment and toxicological assistance to a variety of public and private clients. He specializes in human health and environmental risk assessments, toxicological research, and target cleanup level development. He has performed risk assessments for numerous Superfund, RCRA, and private and public client facilities throughout the United States. In addition, he researches toxicological data for various projects and assists senior toxicologists in chemical fate and transport modeling, risk-based cleanup level development, and development of risk assessment documents. Mr. Bowland, and is also based in MWH's Sacramento office.

Ms. Carin Loy, MS, MWH. Ms. Loy has over 13 years of experience in the environmental field. With an academic background in both Chemistry (B.S.) and Ecology (M.S.), she provides ecological risk assessment support to both commercial and government clients in California. Comfortable with mathematical modeling and other forms of bioassessment, Ms. Loy has designed and implemented several studies, not all traditional, that have resulted in appropriately protective clean-up and re-use of chemically-impacted property. Mrs. Loy's masters' thesis addressed how riverine riparian vegetation adapts to reservoir shores. Ms. Loy possesses substantial experience with ecological risk assessments associated with coastal salt marshes and other wetland environments of the San Francisco and Suisun Bays. Ms. Loy is also based in MWH's Sacramento office.

D. COST

1. Budget

The detailed budget and budget justification are included in the web forms and not included here.

2. Cost-Sharing

No other funding and cost-sharing commitments are associated with the proposal.

E. LOCAL INVOLVEMENT

The proposed ecological risk assessment study has the endorsement of Mr. John Salmonson, Chairman of the California Fertilizer Inspection Advisory Board (Attachment C), California Department of Food and Agriculture (CDFA). This Board is appointed by the Secretary of Food and Agriculture and is advisory to the Secretary. The Advisory Board makes recommendations to the Secretary pertaining to issues that are in the interests of the fertilizer industry and the public. The Board also makes recommendations pertaining to the Department's enforcement program, research and education programs, and regulations. The Advisory Board, and staff in the Agricultural Commodities and Regulatory Services (ACRS) branch of CDFA, will be integrally involved in the project planning and development, and outcome and results. Because the proposed study will be conducted exclusively in an office environment, notification and

coordination with property owners, local government, watershed groups, local conservancies, and the general public will not be required.

F. COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

See attached letter from Ahmad Hakim-Elahi, Director of Sponsored Programs, Office of the Vice Chancellor for Research Sponsored Programs, UC Davis.

G. LITERATURE CITED

California Department of Fish and Game, 1997, California Wildlife Habitat Relationships System Database

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FIGURES

Figure 1. Conceptual Study Model

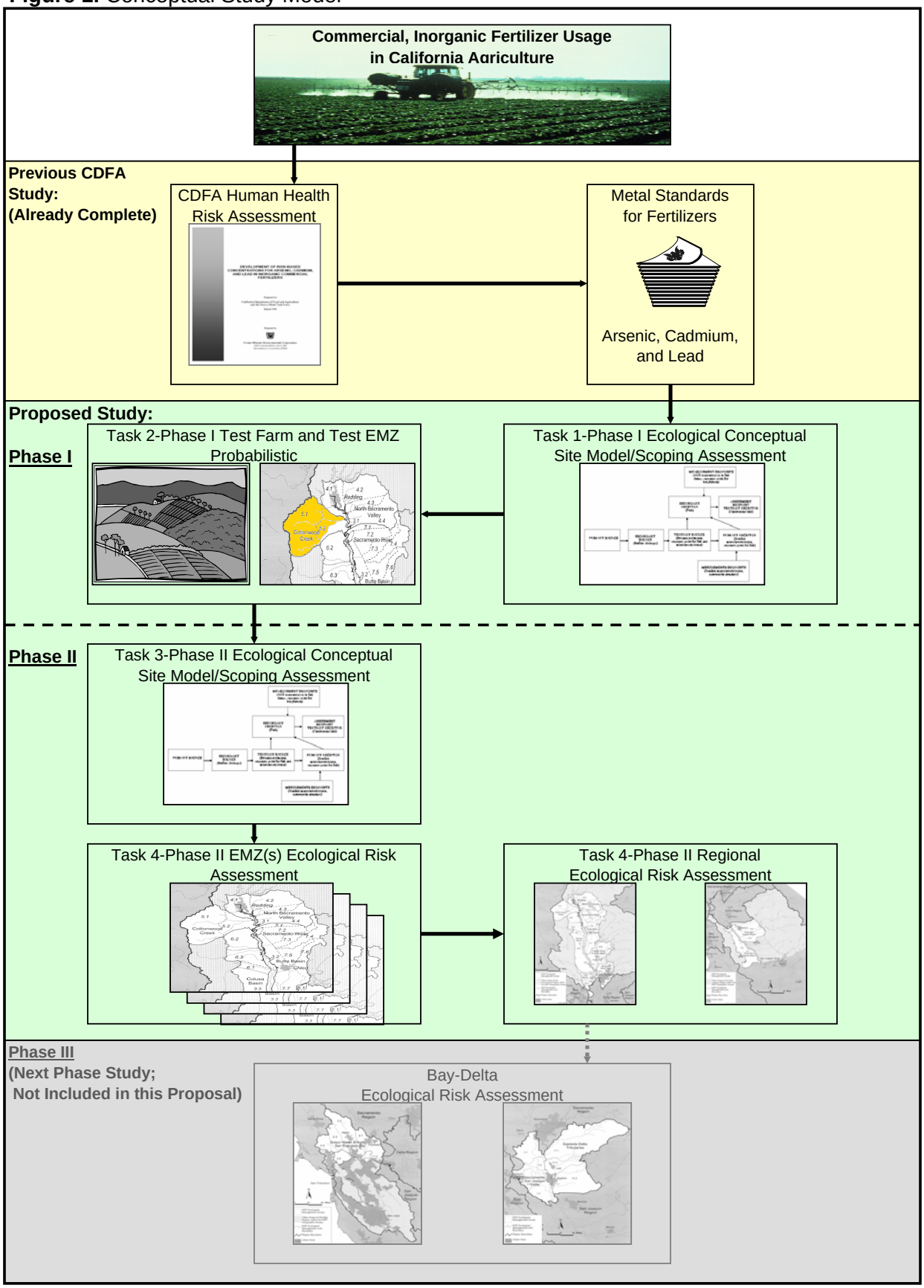
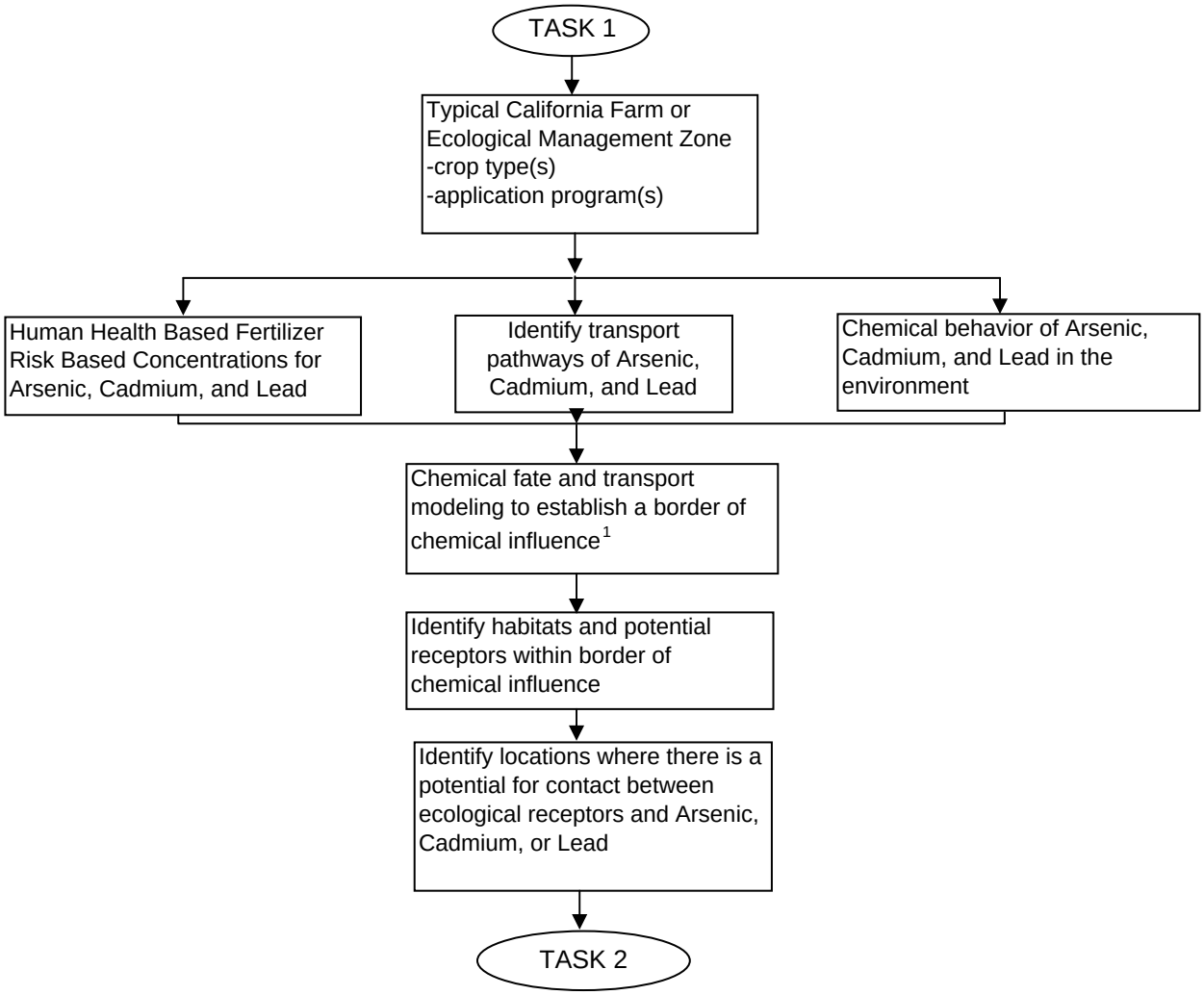
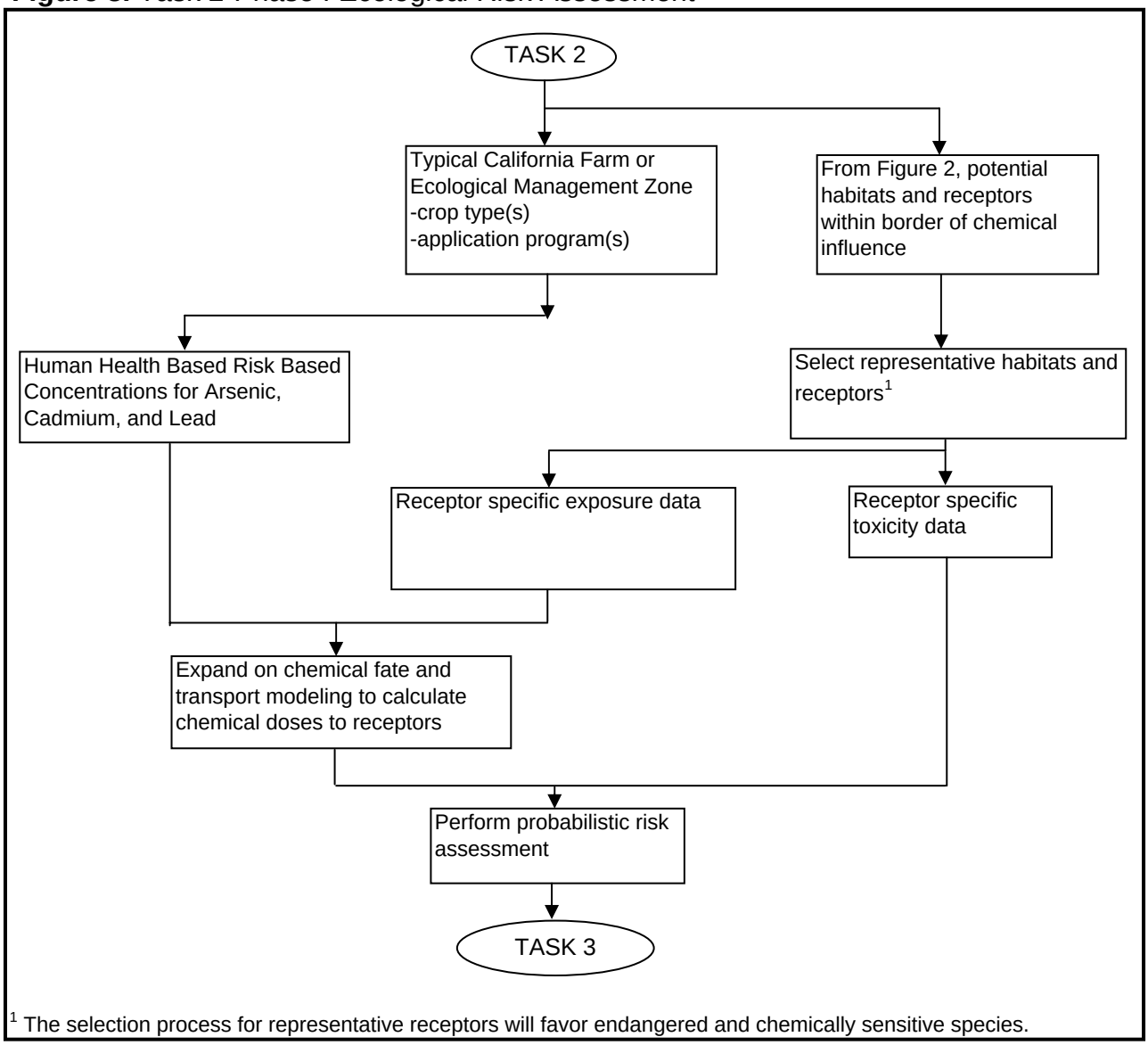


Figure 2. Task 1-Phase I Scoping Assessment



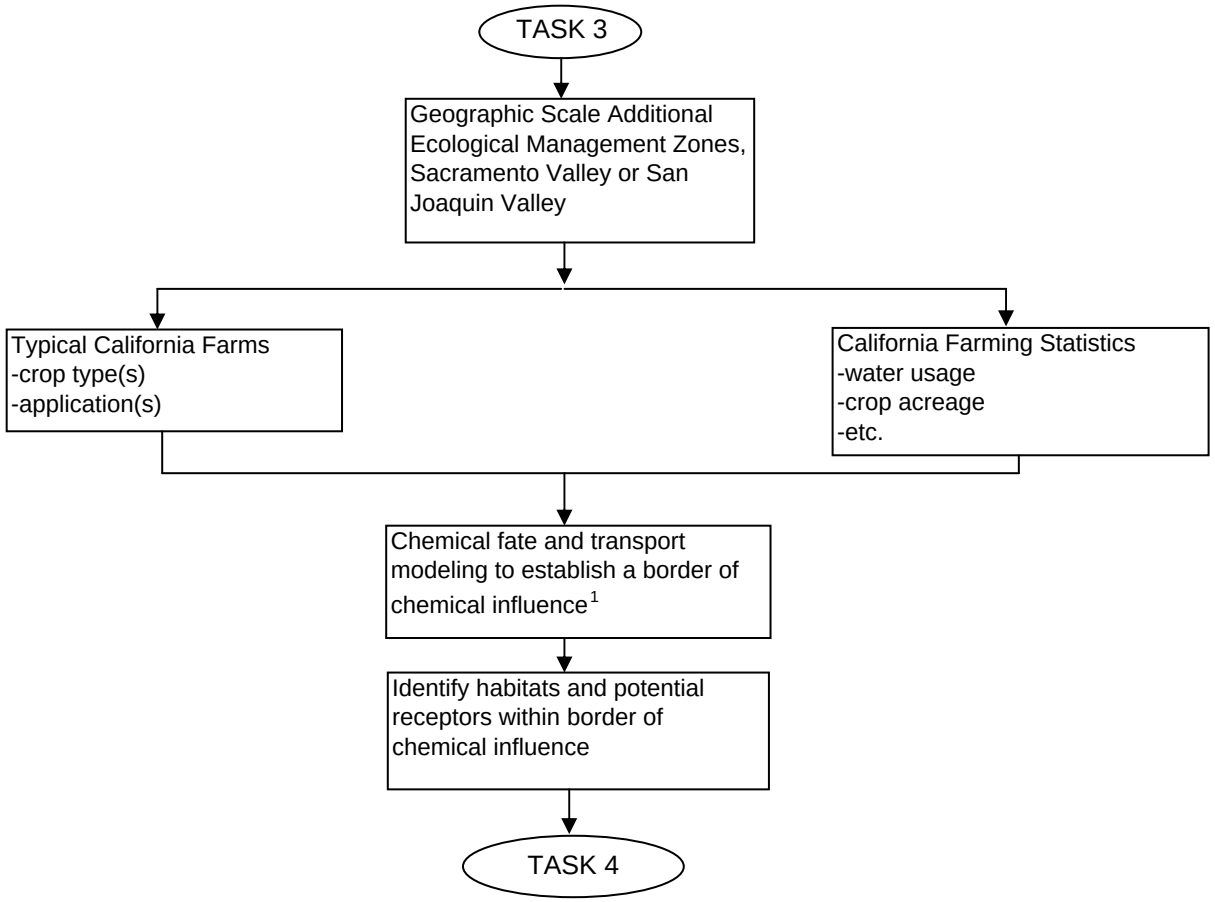
[1] The border of chemical influence of a single farm or ecological management zone is assumed to be the location where the chemical can no longer be detected (the edge of the plume). It is assumed that within this border, field measurements can potentially be made to validate exposure assumptions made in the Phase I ERA (Figure 3).

Figure 3. Task 2-Phase I Ecological Risk Assessment



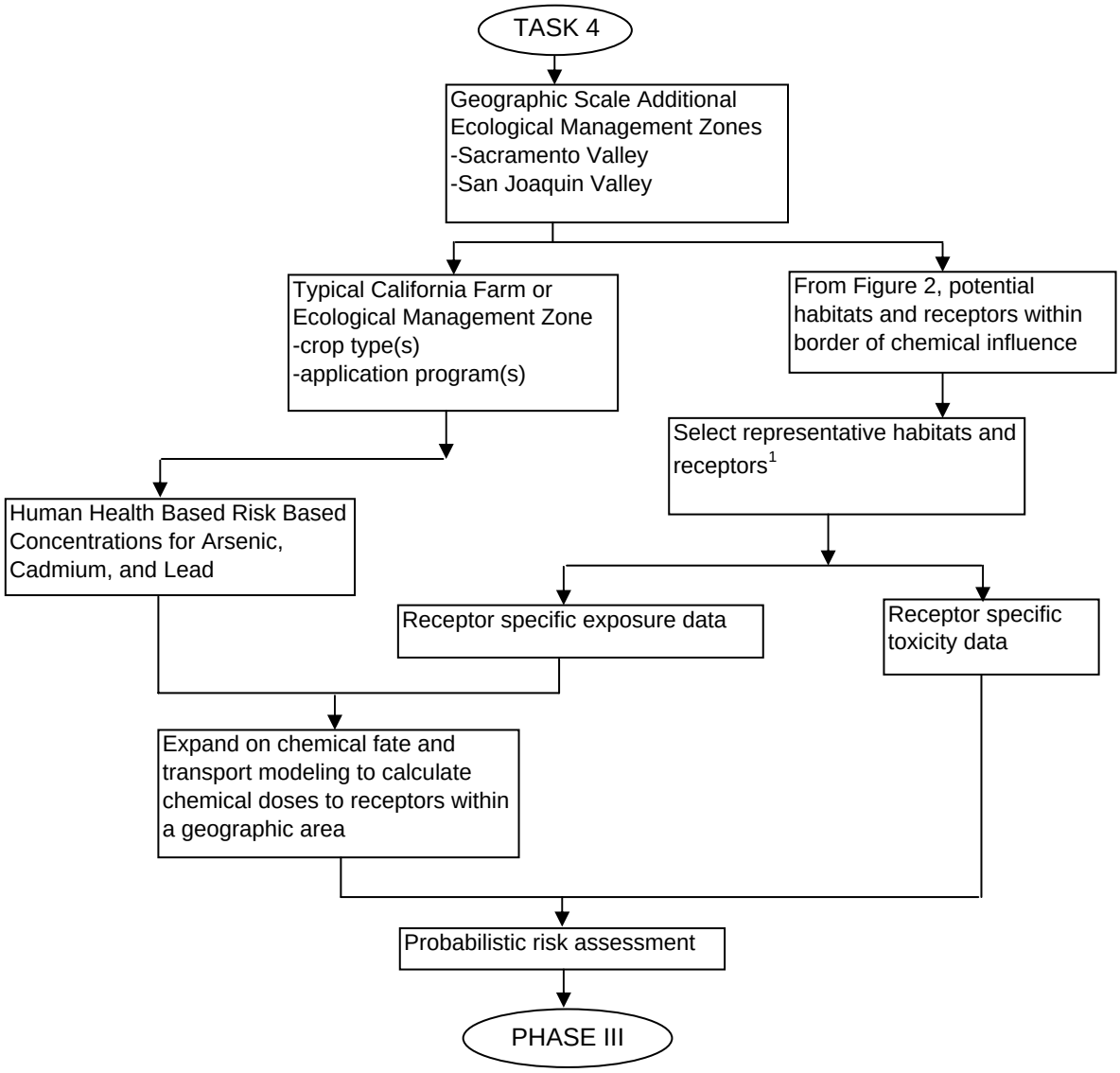
[1] The selection process for representative receptors will favor endangered and chemically sensitive species.

Figure 4. Task 3-Phase II Scoping Assessment



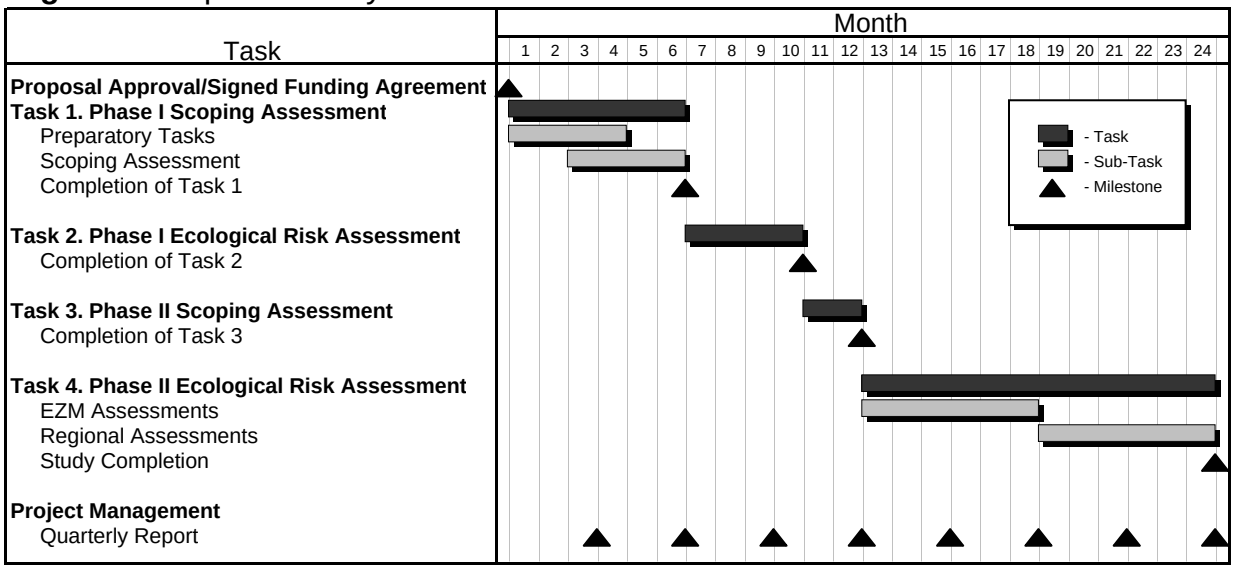
[1] Uncertainties associated with model assumptions make field validation of input parameters problematic; overlaps with single farm scenario.

Figure 5. Task 4-Phase II Ecological Risk Assessment



[1] The selection process for representative receptors will favor endangered and chemically sensitive species; may overlap with single farm scenario.

Figure 6. Proposed Study Schedule



ATTACHMENTS

ATTACHMENT A

Project Tasks

Phase I

A. Task 1: Test-Farm and Test-Ecological Management Zone Scoping Assessment

1. Preparatory Tasks

- Inventory California's Central Valley ecological management zones[1] by the same farm crops evaluated for RBC development (single crop, forage crop, multi-crop and rice).
- Building on the RBC development effort, research fertilizer application routines for each type of farm crop and identify regional differences, if any.
- Building on the RBC development effort, describe and quantify Central Valley ambient chemical conditions for the metals of interest (MOI): arsenic, cadmium and lead.
- Building on the RBC development effort, compile physical parameters used for modeling MOI fate and transport in the environment. When multiple valid, peer-reviewed parameters are in the literature compile all results.
- Determine California-specific Kd values for the MOI, a source of significant uncertainty in the RBC development process.

2. Scoping Assessment

- Select a "test" ecological management zone based on preparatory work.
- For each of the four farm crop scenarios, perform air, groundwater and surface water modeling to determine the theoretical distance an MOI could travel from a farm located within the test ecological management zone and from a collection of farms in the ecological management zone.
- Identify ecological habitats, flora and fauna that could reside within the distance the MOIs could travel.
- Perform an ecological Scoping Assessment per DTSC, 1996, identifying potentially complete pathways from fertilizer-related MOIs and ecological habitats.

B. Task 2: Test-Farm and Test Ecological Management Zone Probabilistic Ecological Risk Assessment

- Select representative receptors from the habitats located within the influence of the MOI.
- Research the life histories of each of the representative receptors.
- For each representative receptor, compile life history information that affects chemical exposure. When multiple valid, peer-reviewed parameters are in the literature compile all results.
- Perform comprehensive literature search to find MOI toxicity reference values (TRVs) for representative receptors. Consider two sets of TRVs, one with population level endpoints and one with individual level endpoints.
- Compile TRVs into a database.
    - Develop a method for weighing different studies based on experimental quality and test endpoints.
    - Modify TRVs to account for differences between test species and representative species.
- Use fate and transport and food chain modeling to estimate potential exposure doses to representative receptors from application of fertilizer with concentrations of MOI at their risk-based concentrations (RBC)
- Compare modeled doses with TRVs using probabilistic models

Phase II

A. Scoping and Probablistic Ecological Risk Assessments for the Remaining Eleven Ecological Management Zones.

- Perform a Scoping Assessment and Ecological Risk Assessment for the remaining Central Valley Ecological Management Zones.

B. San Joaquin Valley Scoping and Probabilistic Ecological Risk Assessment

- Perform a Scoping Assessment for the San Joaquin Valley.
- Use fate and transport and food chain modeling to estimate potential exposure doses from fertilizer application on all San Joaquin Valley farms to representative receptors in the San Joaquin Valley
- Compare modeled doses with TRVs using probabilistic models

B. Sacramento Valley Probabilistic Ecological Risk Assessment

- Perform a Scoping Assessment for the Sacramento Valley.
- Use fate and transport and food chain modeling to estimate potential exposure doses to representative receptors in the Sacramento Valley.
- Compare modeled doses with TRVs using probabilistic models.

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[1] Twelve of the fourteen ecological management zones will be assessed in this study: Sacramento River, North Sacramento Valley, Cottonwood Creek, Colusa Basin, Butte Basin, Feather River/Sutter Basin, American River Basin, Yolo Basin, Eastside Delta Tributaries, San Joaquin River, East San Joaquin, and West San Joaquin.

ATTACHMENT B

PROPOSED TEXT

Department of Food & Agriculture
TITLE 3. CALIFORNIA CODE OF REGULATIONS
SECTIONS 2302 and 2303

Underline means original proposed text
~~Strikethrough~~ means deletions from the original proposed text
Double underline means revisions to the original proposed text

Adopt Section 2302 to read:

2302. Non-Nutritive Standards.

(a) Inorganic commercial fertilizer and agricultural mineral products shall not exceed the following standards for the non-nutrient metals arsenic, cadmium and lead:

1. For each percent iron, manganese or zinc, the fertilizing material shall not exceed the following concentrations of non-nutrient metals: arsenic, 13 parts per million; cadmium, 12 parts per million; lead, 140 parts per million.

2. For each percent available phosphate (P_2O_5), the fertilizing material shall not exceed the following concentrations of non-nutrient metals: ~~arsenic, 2 parts per million; cadmium, 4 parts per million; lead, 20 parts per million.~~

(i) Effective January 1, 2002 through December 31, 2002: arsenic, 4 parts per million; cadmium, 6 parts per million; lead, 20 parts per million.

(ii) Effective January 1, 2003 through December 31, 2003: arsenic, 3 parts per million; cadmium, 5 parts per million; lead, 20 parts per million.

(iii) Effective January 1, 2004 : arsenic, 2 parts per million; cadmium, 4 parts per million; lead, 20 parts per million.

3. The concentration limits are applied as follows:

(i) For micronutrient materials with guaranteed available iron, manganese or zinc multiply the percentage of guaranteed micronutrient material (Minor

Element) by the arsenic, cadmium and lead maximum concentrations as expressed in parts per million (ppm). Example: A 12% Iron product will have the following limits: arsenic, 156 parts per million (13 ppm X 12); cadmium, 144 parts per million (12 ppm X 12); and lead, 1,680 parts per million (140 ppm X 12).

(ii) For phosphate (P_2O_5) materials multiply the guaranteed percentage of P_2O_5 by the arsenic, cadmium and lead maximum concentrations as expressed in parts per million (ppm). Example: from January 1, 2002 through December 31, 2002: A guaranteed available 52% (P_2O_5) phosphate product will have the following limits: arsenic ~~104~~ 208 parts per million (~~2~~ 4 ppm X 52); cadmium ~~208~~ 312 parts per million (~~4~~ 6 ppm X 52); and lead 1,040 parts per million (20 ppm X 52).

4. For specialty fertilizers that guarantee less than 6% available phosphate (P_2O_5) but make no micronutrient claim, the maximum allowable concentrations of non-nutrient metals shall not exceed: ~~arsenic, 10 parts per million, cadmium 20 parts per million, and lead 100 parts per million.~~

(i) Effective January 1, 2002 through December 31, 2002 specialty fertilizers shall not exceed: arsenic, 20 parts per million; cadmium, 30 parts per million; and lead, 100 parts per million.

(ii) Effective January 1, 2003 through December 31, 2003 specialty fertilizers shall not exceed: arsenic, 15 parts per million; cadmium, 25 parts per million; and lead, 100 parts per million.

(iii) Effective January 1, 2004 specialty fertilizers shall not exceed: arsenic, 10 parts per million; cadmium, 20 parts per million; and lead, 100 parts per million.

5. For specialty fertilizers that guarantee less than 6% available phosphate

(P_2O_5) and make a micronutrient claim, multiply the guaranteed percentage of micronutrient by the arsenic, cadmium and lead maximum concentrations as expressed in parts per million (ppm) and add the following values to that total: ~~arsenic, 10 parts per million, cadmium 20 parts per million, and lead 100 parts per million.~~

(i) Effective January 1, 2002 through December 31, 2002 add: arsenic, 20 parts per million; cadmium, 30 parts per million; and lead, 100 parts per million.

(ii) Effective January 1, 2003 through December 31, 2003 add: arsenic, 15 parts per million; cadmium 25 parts per million; and lead 100 parts per million.

(iii) Effective January 1, 2004 add: arsenic, 10 parts per million; cadmium, 20 parts per million; and lead 100 parts per million.

6. The concentration limits are applied as follows:

(i) A guaranteed available 3% (P_2O_5) phosphate product with 2% guaranteed zinc will have the following limits. Example: from January 1, 2002 through December 31, 2002: arsenic, ~~36~~ 46 parts per million (13 ppm X 2 zinc = 26 ppm + ~~10~~ 20 ppm); cadmium, ~~44~~ 54 parts per million (12 ppm X 2 zinc = 24 ppm + ~~20~~ 30 ppm); and lead, 380 parts per million (140 ppm X 2 zinc = 280 ppm + 100 ppm).

(b) Waste and hazardous waste shall be defined as specified in Title 22, CCR Division 4.5, Chapter 11 – Identification and Listing of Hazardous Waste.

(c) Recyclable material used in fertilizing material manufacture shall meet all applicable requirements in the Code of Federal Regulations, Chapter 1, Title 40, Part 266, Subpart C – Recyclable Materials Used In a Manner Constituting Disposal.

(d) Recyclable material used in fertilizing material manufacture shall be sampled and tested in accordance with procedures specified in Title 22, CCR, Division 4.5, Chapter 11 – Identification and Listing of Hazardous Waste.

1. A copy of test results shall be submitted to the department for each source of recyclable material used in the manufacture of zinc, manganese or iron products utilized as a base fertilizing material ingredient. Additional test results shall not be required by the department unless the process or operation generating the recyclable material changes.

(e) No recyclable material may be used in fertilizing material manufacture if its use is denied pursuant to Title 22, CCR, Division 4.5, Chapter 16, Article 8.5 – Requirements for Management of Recyclable Materials Used in Agriculture.

(f) No recyclable hazardous waste may be used in fertilizing material manufacture unless the generator of such recyclable hazardous waste complies with Title 22, CCR, Division 4.5, Chapter 16, Article 8.5 – Requirements for Management of Recyclable Materials Used in Agriculture.

(g) By December 31, 2004, the department shall publish a report concerning results of research that evaluates the protectiveness of these regulations on both human health and the environment. Additionally, the report shall include an analysis of and recommendations for regulating cobalt, copper, mercury, molybdenum, nickel, selenium and dioxins.

Authority: Section 407, 14502, and 14682 of the Food and Agriculture Code.
Reference: Section 14682 of the Food and Agriculture Code.

Amend Section 2303 to read:

2303. Labeling Requirements.

(r) The manufacturer of any base fertilizing material ingredient that claims iron, manganese, zinc or phosphates shall provide a guarantee statement that the product does not exceed standards established for arsenic, cadmium and lead.

1. For purposes of the labeling guarantee, base fertilizing material ingredient shall be defined as phosphate, zinc, manganese, or iron products utilized as material ingredient in blended or formulated fertilizing material products. Examples of such base fertilizing material ingredients include, but are not limited to, phosphoric acid, monoammonium phosphate, diammonium phosphate, 36% zinc product, 12% iron product, 7% manganese product.

2. The guarantee statement shall report in parts per million the maximum total concentration of arsenic, cadmium and lead in the base fertilizing material ingredient.

(s) Labels and packaged product labels for commercial fertilizer and agricultural mineral products, with the exception of gypsum, liming materials, manure, wood or coal fly ash ~~and~~, sewage sludge, composted products, potting soils, potting mix, blood meal, bone meal, feather meal, kelp meal or seaweed, cottonseed meal, fish meal, sphagnum moss and seed mix shall include either an informational statement of laboratory test results or provide an informational statement providing the maximum levels of arsenic, cadmium, cobalt, copper, lead, mercury, molybdenum, nickel and selenium. In lieu of a statement on the label, the information may be provided by either of the following statements:

"Information regarding the contents and levels of metals in this product is available by calling 1-800-XXX-XXXX."

Or

"Information regarding the contents and levels of metals in this product is available on the Internet at http://www.regulatory-info-xx.com." Each registrant must substitute a unique alphanumeric identifier for "xx". This statement may be used only if the licensee establishes and maintains the Internet site; there is a clearly visible, direct hyperlink to a government web site; and, the Internet site contains no advertising or company-specific information. A government web site internet

address on the label is an acceptable alternative to a web site established and maintained by the licensee.

(t) Testing methodology for the informational statement of laboratory test results shall conform to either sample preparation method 3050B or 3051A and conform to analysis methods as described in US EPA Publication SW-846.

(u) Labeling provisions in Section 2303 (r) shall be met no later than ~~July 1, 2001~~ January 1, 2002. Labeling provisions in Section 2303 (s) shall be met no later than ~~December 31, 2001~~ July 1, 2002 for all products entering into channels of trade.

(v) The publication of inaccurate information regarding the contents and levels of metals is a misbranding violation pursuant to Article 14681 of the Food and Agriculture Code.

Authority: Sections 407, 14502, and 14631 of the Food and Agricultural Code.
Reference: Section 14631 of the Food and Agricultural Code.

ATTACHMENT C

MONTEREY CHEMICAL COMPANY

• Specialty Agricultural Chemicals
• Micronutrients for Agriculture and Feed
• Product Development
• Custom Packaging and Formulating

October 4, 2001

Ronald S. Tjeerdema Ph.D., DABT
Professor, Dept. of Environmental Toxicology
College of Agricultural and Environmental Sciences
University of California, Davis
Davis, California 95616-8588

Dear Dr. Tjeerdema;

We have had an opportunity to read over the project outline submitted by the MWH firm to study the risk based concentrations of the metals Arsenic, Cadmium, and lead that could be derived from various fertilizer applications.

This study is needed to document the current accepted risk based standards and will add the additional science needed to develop new standards for the future.

There is very little data in this area and we strongly endorse CALFED to accept this important study. The more scientific knowledge we can build upon, the better our long term decision making can be that impacts our entire ecosystem.

Sincerely,

John F. Salmonson
President
Chairman – CDFA Fertilizer Inspection Advisory Board

JFS/hac

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