ERP Proposal Application Form

For DFG use only	
Proposal No.	Region

(Pages A13-A18)

Section 1: Summary Information

1. Project title:	Wetland and Rice Management to Limit Methylmercury Production and Export
2. Applicant name:	U.S. Geological Survey
3. Contact person:	Lisamarie Windham-Myers
4. Address:	345 Middlefield Road, MS 480
5. City, State, Zip:	Menlo Park, CA 94025
6. Telephone #:	650-329-4447
7. Fax #:	650-329-4463
8. Email address:	lwindham@usgs.goc
9. Agency Type:	Federal Agency ☒ State Agency ☐ Local Agency ☐ Nonprofit Organization ☐ University (CSU/UC) ☐ Native American Indian Tribe ☐
10. Certified nonprofit organization:	Yes ☐ No ☒
11. New grantee:	Yes ☒ No ☐
12. Amount requested:	$197,416
13. Total project cost:	$1,251,465 ($1,054,049 = total project cost of current research project, 2010-2013)
14. Topic Area(s):	Ecosystem Water and Sediment Quality
15. ERP Project type:	Pilot/Demonstration (also Monitoring)
16. Ecosystem Element:	Agricultural Lands (also, Freshwater Emergent Wetlands, Contaminants)
17. Water Quality Constituent:	Mercury (also Organic Carbon)
18. At-Risk species benefited:	Greater Sandhill Crane, Giant garter snake, Western pond turtle
19. Project objectives:	We will test DRERIP-model predictions that organic carbon management on rice fields and permanent flooding of freshwater emergent marshes can limit methylmercury production, bioaccumulation (in rice and biosentinel fish), and export to the Cosumnes River.
20. Time frame:	September 2011-September 2013

Section 2: Location Information

1. Township, Range, Section: and the 7.5 USGS Quad map name.	USGS 7.5 Quad = Galt Township: 5N Range: 6E http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/folsom/plans.Par.67798.File.dat/CRP_Final_Mgmt_Plan.pdf
2. Latitude, Longitude (in decimal degrees, Geographic, NAD83):	Bounded by the polygon as follows: NW corner = 38.286494, -121.456953; NE corner = 38.288021, -121.394965; SE corner = 38.257684, -121.381868; SW corner = 38.247441, -121.443804
3. Location description:	The Cosumnes River Preserve covers approximately 46,000 acres in southern Sacramento County within portions of six townships: T5N, R4E; T5N, R5E; T5N, R6E; T6N, R4E; T6N, R5E; and T6N, R6E. The Preserve is situated approximately 15 miles south of Sacramento, and 25 miles north of Stockton they State Highway 99 corridor. This project encompasses more than 600 acres of rice fields, seasonal wetlands, and permanent wetlands, as well as slough channels that either provide water, or receive drainage from managed wetlands, and several locations within the Cosumnes River itself (Figure 2, 3). These areas lie within a region that was identified in the Central Valley Methylmercury TMDL (http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/) as a hotspot for methylmercury contamination and ultimate discharge into the Delta. The Cosumnes watershed contains vast wetland habitats and rice agriculture, which are known to produce methylmercury.
4. County(ies):	Sacramento County
5. Directions:	From Sacramento, go south on I5 to Twin Cities Rd. Follow signs to Cosumnes River Preserve. Access will be provided by BLM Preserve Manager
6. Ecological Management Region:	EMZ 2- Alluvial Floodplain (Figure 1 in ERPP, Volume 4, Maps)
7. Ecological Management Zone(s):	East Side Delta Tributaries (Figure 16 in ERPP: Volume 4, Maps)
8. Ecological Management Unit(s):	Cosumnes River Ecological Unit (Page 328 in ERPP:Volume 2, Ecological Management Zone Visions)
9. Watershed Plan(s):	Delta Methylmercury TMDL and Basin Plan Amendment http://www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/
10. Project area:	600 acres
11. Land use statement:	Rice agriculture, floodplain, wetlands, restoration
12. Project area ownership:	% Private = 0 % State =0 % Federal = 100
13. Project area with landowners support of proposal:	Letter attached below from Harry McQuillen, BLM preserve manager Also see appended Scope of work for the EPA(319h)-funded project, 2010-2013, described herein

Section 3: Landowners, Access and Permits

1. Landowners Granting Access for Project: (Please attach provisional access agreement[s]) Letter attached below from Harry McQuillen, BLM preserve manager	
2. Owner Interest: Letter attached below from Harry McQuillen, BLM preserve manager	
3. Permits:	Access is granted and any associated permits have been obtained by Harry McQuillen and Collin Eagles-Smith to meet EPA CWA 319(h) requirements.
4. Lead CEQA agency:	As data sampling on federal land, no CEQA is required. A NEPA analysis was completed and available from BLM preserve manager, Harry McQuillen.
5. Required mitigation:	Yes ☐ No ☒

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Mother Lode Field Office
5152 Hillsdale Circle
El Dorado Hills, CA 95762
www.ca.blm.gov/motherlode

February 28, 2011

Lisamarie Windham-Myers, Ph.D.
U.S. Geological Survey
345 Middlefield Road / MS 480
Menlo Park, CA 94025

Lisa:

This letter is to confirm our support as a cooperating agency for the CalFed Ecosystem Restoration Program's grant proposal entitled: "Wetland and Rice Management to Limit Methylmercury Production and Export." If funded, the proposed project will be part of our collaborative effort with USGS *et al.* to understand how best to control methylmercury production on our managed lands; thereby reducing methylmercury discharges to the Delta as required for Phase I implementation of the State TMDL.

The Bureau of Land Management (BLM) is one of several land-owning partners at the Cosumnes River Preserve. Since 1994 the BLM has served as the lead federal agency at the Preserve. The majority of the BLM-owned lands at the Preserve are now restored to and managed as freshwater wetlands and organic rice that support thousands of wintering migratory waterfowl and waterbirds each year. The proposed project will greatly increase our understanding of how the BMP's that we are currently testing are affecting the labile organic carbon and subsequent production of methymercury in our wetland units and rice fields. Without an understanding of the relationship between the remaining organic matter/carbon and the production of methylmercury, we cannot determine if the BMPs will in turn have an adverse effect on the production of invertebrates and the behavior of the birds that rely on our wetland habitats for their survival.

As a cooperating agency, we will participate fully in the implementation of the project through on-the-ground, day-to-day management of the wetlands and organic rice; the granting of access to areas generally closed to the public; the participation in data collection, draft and final report reviews as requested; conducting educational and outreach efforts with the public and other collaborators as needed; and any other aspect of the proposed project where our assistance can be of value to ensure its successful completion.

If you have any questions or need additional information from us, please contact me at 916-838-8475 or via email at hmcquill@blm.gov.

Best Regards,

Harry L. McQuillen
Preserve Manager

Section 4: Project Objectives Outline

1. **List task information:**

This project is directly responsive to the stated CALFED ERP's **Goal 6:** Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people. **Objective 1:** Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

2. **Additional objectives:**

This study addresses multiple ERP goals in terms of evaluating the functional responses of shallow water habitats to management actions. These include:

Goal 1: Endangered and Other At-risk Species and Native Biotic Communities

Greater sandhill cranes, among other species, overwinter on Cosumnes River Preserve grounds. The extent to which water and carbon management can reduce the MeHg concentrations in their omnivorous diets (rice, fish, insects) is an important consideration for migrating and resident species of special status.

Goal 2: Ecological Processes

Restoration plans for floodplain processes within the Cosumnes River Preserve and along the entire river can benefit from this demonstration project for carbon and water management to limit MeHg production and export.

Goal 4: Habitats

Seasonal wetlands in the Central Valley are an important restoration goal for various harvested and protected species. Because management approaches differ based on habitat goals, developing and integrating DRERIP models on disparate topics (e.g. mercury contamination, fish habitat, and floodplain processes) can help optimize site-specific solutions within the larger watershed context. Key species to benefit from this study include: splittail, chinook salmon, steelhead trout, native resident fishes, giant garter snake, western pond turtle, Swainson's hawk, greater sandhill crane, waterfowl, and native plant communities.

3. **Source(s) of above information:**

ERP PSP, December 2010. APPENDIX D: Ecosystem Restoration Strategic Goals and Objectives

ERPP_Volume 2 (2000): Ecological Management Zone Visions (Available at http://www.dfg.ca.gov/erp/reports_docs.asp)

Ecosystem Restoration Program, July 2010. Conservation Strategy for Stage 2 Implementation Sacramento-San Joaquin Delta, Ecological Management Zone. Available online at: http://www.dfg.ca.gov/erp/reports_docs.asp

Section 5: Conflict of Interest

Project personnel for the EPA-funded project which this proposal seeks to supplement, are listed below.

Organization	Name	Email	Phone
BLM	Harry McQuillen, M.S.	hmcquill@blm.gov	916-683-1701
USGS	Collin Eagles-Smith, Ph.D	Ceagles-smith@usgs.gov	530-754-8130
USGS	Josh Ackerman, Ph.D	jackerman@usgs.gov	530-752-0485
USGS	Jacob Fleck, M.S.	jafleck@usgs.gov	916-278-3063
CalDFG	Mark Stephenson	mstephenson@mlml.calstate.edu	831-771-4177
CalDFG	Wes Heim, M.S.	whein@mlml.calstate.edu	831-771-4177
BLM	Mark Ackerman	mackerma@blm.gov	916-684-5083
BLM	Holden Brink, Ph.D	hbrink@blm.gov	916-683-1740
SacYolo Vector Control	Marty Scholl	mscholl@fightthebite.net	916-685-1022
Nature Conservancy	Sally Liu, M.S.	sliu@tnc.org	415-963-6605
Larry Walker and Associates	Stephen McCord, Ph.D	sam@lwa.com	530-753-6400
US Fish and Wildlife Service	Thomas Maurer	Thomas_maurer@fws.gov	916-414-6594
Ducks Unlimited	Jeff McCreary	jmmccreary@ducks.org	916-852-2000

Additional input was provided by:

Marvin-DiPasquale, Mark U.S. Geological Survey Project Chief, Biogeochemistry at Regional Scales

Section 6: Project Tasks and Results Outline

1. Detailed Project Description

This project tests potential management practices to limit toxic methylmercury (MeHg) production in shallow-water wetlands using a federally-funded (EPA CWA 319(h)) field manipulation of land use practices across several dominant wetland types within the Central Valley (rice fields, seasonal wetlands, and permanent wetlands). This replicated and explicit field test of management practices on more than 600 acres along the Cosumnes River provides a unique opportunity to test the DRERIP-MCM (Delta Regional Ecosystem Restoration Implementation Plan, Mercury Conceptual Model) for sensitivity to field management decisions. Management of post-harvest rice straw is expected to limit available labile organic matter within rice fields. Water management in seasonal wetlands is expected to limit MeHg production and discharge. However, these management effects are not being directly documented in the currently funded project. Field management began across 6 types of wetlands (3 replicates each) in October 2010 and will continue through 2012. Data has not yet been collected, but the response metrics to be measured consist only of biosentinel fish total mercury (THg) concentrations, and aqueous MeHg concentrations on the field. While these are target indicators of TMDL-oriented management effectiveness, the current study lacks key documentation and quantification of field responses to management actions, specifically in regards to the drivers believed to regulate MeHg production – labile carbon and bioavailable mercury (Windham-Myers et al., 2010a). We seek to augment the current monitoring data with process-based information on sediment, water, and plant metrics that can be used to discern mechanisms by which management decisions do or do not lead to differences between fields and years. The process-based information also provides a test of the DRERIP linkages for regional extrapolation. Ultimately, these modifications are expected to reduce MeHg production and discharge to the Sacramento-San Joaquin Delta, but without supplemental process-based data on key factors known to stimulate MeHg production, as well as an estimate of evapoconcentration, the linkage between management actions, bioaccumulation of Hg in fish, and MeHg load reductions will be difficult to document and quantify.

2. Background and Conceptual Models

Mercury contamination of the Sacramento-San Joaquin River Delta (Delta) is a priority issue with the Central Valley Regional Water Quality Control Board (Region 5), and this project directly addresses the preferred approach described by the Regional Board Staff to implement the MeHg Total Maximum Daily Load (TMDL) strategy, currently being developed. Specifically, Phase I of the proposed TMDL consists of approximately 8 years of control studies to evaluate methods for reducing MeHg production and discharge from wetland habitats and irrigated agricultural lands. The current EPA-funded study evaluates several different wetland management and agricultural techniques in an attempt to reduce MeHg production and discharge to the Delta while maintaining ecological and agricultural beneficial uses. We seek to supplement the EPA-funded study with additional process-based measurements that will provide a mechanistic understanding of the extent to which Hg-cycling responses are observed.

The EPA-funded project will implement modifications to land use practices across several dominant wetland types within the Central Valley (rice fields, seasonal wetlands, and permanent wetlands) to reduce MeHg production and discharge to the Sacramento-San Joaquin delta. In rice fields, management of post-harvest rice straw is being modified by two techniques (discing and bailing) to reduce available labile organic matter within rice fields. Surface litter pools and porewater pools of labile carbon (e.g. acetate) have been shown to be a key driver of MeHg production in rice fields and wetlands of the nearby Yolo Bypass (Windham-Myers et al. 2009). Additionally, water management techniques, including perennial and spring-induced hydroperiods, will be tested in historically winter-flooded seasonal wetlands. These hydroperiods are predicted to limit surficial organic matter sources and enhance processes that limit net MeHg production and discharge.

The proposed project will help achieve the water quality goals specified in the TMDL by providing critical information for the development of agricultural best management practices (BMP's) that lower MeHg production within and export from existing wetlands and rice fields, and thus reduce MeHg loading to the Cosumnes River. Specifically, we are implementing land and water use practices to reduce the amount of labile organic material remaining in seasonal fields (either rice fields or seasonal wetlands) prior to flooding. Recent experimental and comparative studies within the Yolo Bypass have shown that labile organic carbon was a primary driver for sediment MeHg production within seasonal wetlands. By limiting the organic carbon content and altering the timing of wetland inundation through land and water management practices, we anticipate substantial reductions in MeHg production and export. This study incorporates a suite of management practices to evaluate ways to reduce MeHg pollution to the Central Valley. These include adjusting hydrology to control timing and duration of wetland inundation, and altering harvest practices in rice agriculture to alter the amount of residual organic matter that remains on fields post-harvest.

In summary, anaerobic bacteria (sulfate- and iron-reducing groups) actively convert inorganic Hg(II) to MeHg during times of inundation, when sediments become anoxic. In order for this to occur, the following general conditions must exist:

1. anoxic conditions
2. available oxidized sulfur (sulfate) or iron (Fe(III))
3. limited reduced sulfur (e.g. sulfide)
4. bioavailable inorganic mercury
5. labile organic carbon source

Of these parameters, labile organic carbon was shown to be an important limiting factor driving MeHg production in wetlands and rice fields within multiple wetland types (Windham-Myers et al., 2009), and especially in the nearby Yolo Bypass Wildlife Area. Fortunately, availability of organic matter may be readily manipulated and lowered to potentially reduce MeHg production. In this project, BLM and TNC land managers will engage water management and rice cultivation practices that are likely to reduce the amount of organic matter on the sediment surface. Importantly, these approaches are practical and could be used throughout the Central Valley as BMPs if they are demonstrated to be effective. Specifically, in one treatment scenario for rice fields, the residual straw has and will continue to be tilled deep into the soil to move the organic matter below the top layer of soil where most MeHg production occurs. In a second treatment, residual straw is being removed from the surface and bailed in several fields to remove the organic matter from the surface entirely. In seasonal wetland habitats we will flood wetlands for either 120 days (spring-flooded), or leave them inundated from fall through summer (fall-flooded) to alter vegetation growth and wetting/drying cycles thereby altering the amount of organic matter in wetlands among flooding treatments.

With EPA 319(h) funds, the success of these management practices will be measured as the responses of MeHg concentrations in fish and surface water. First, MeHg concentrations in the in-flowing and out-flowing water of each wetland will be compared. Second, caged western mosquitofish will be deployed at inlets and outlets of each wetland to measure Hg bioaccumulation in fish. This approach provides an integrative measure of water MeHg concentrations which is considered superior to point-in-time estimates provided directly by limited and highly variable water measurements. In addition to within-wetland loading, the EPA-funded PI's will evaluate the impact of these management practices to the Cosumnes River by deploying caged fish and collecting water samples from both the source-water and receiving water sloughs, as well as in the River itself upstream and downstream of the wetland complex.

In conjunction with these broader EPA-funded manipulations and metrics referenced above, this supplementary proposal seeks to test the following hypotheses:

Hypothesis 1: Rice straw management by tilling or bailing reduces sediment labile organic matter during winter flooding, and during the growing season.

Hypothesis 2: Pools of MeHg in sediment and porewater are lowest where and when sediment labile organic matter is lowest.

Hypothesis 3: Field-based differences in aqueous MeHg concentrations and Hg bioaccumulation in biosentinel fish are correlated with indices of sediment MeHg production.

Hypothesis 4: MeHg concentrations in seeds (rice and bulrush) are reduced in by the proposed carbon and water management actions.

Hypothesis 5: Surface water measurements of dissolved organic matter will provide insight and predictive value for estimating MeHg concentrations.

These hypotheses are proposed in close collaboration with the PI's of the EPA-funded proposal (Josh Ackerman, Collin Eagles-Smith, Jacob Fleck, Mark Stephenson, Harry McQuillen: contact information provided in Section 5). Monitoring and tracking the project will occur through regular meetings with the wetlands managers and farmers. Water levels in seasonal ponds will be monitored on a weekly basis during the implementation periods, and we will work closely with farmers to ensure that the appropriate post-harvest measures are incorporated in selected rice fields. To assist farmers and ensure cooperation, their additional expenses associated with rice straw management have been offset, considering the additional labor beyond their normal operations. Specifically, $85K has been provided to subsidize the cost of tilling and bailing rice straw as an incentive to ensure full farmer participation. The proposal described here takes advantage of these current manipulative operations to test DRERIP-proposed strategies to control MeHg production, bioaccumulation and export. If we can determine the conditions under which a management activity substantially reduces MeHg production more than another, then managers will be able to implement use of that management activity at additional sites to further reduce MeHg export to the Delta in future years.

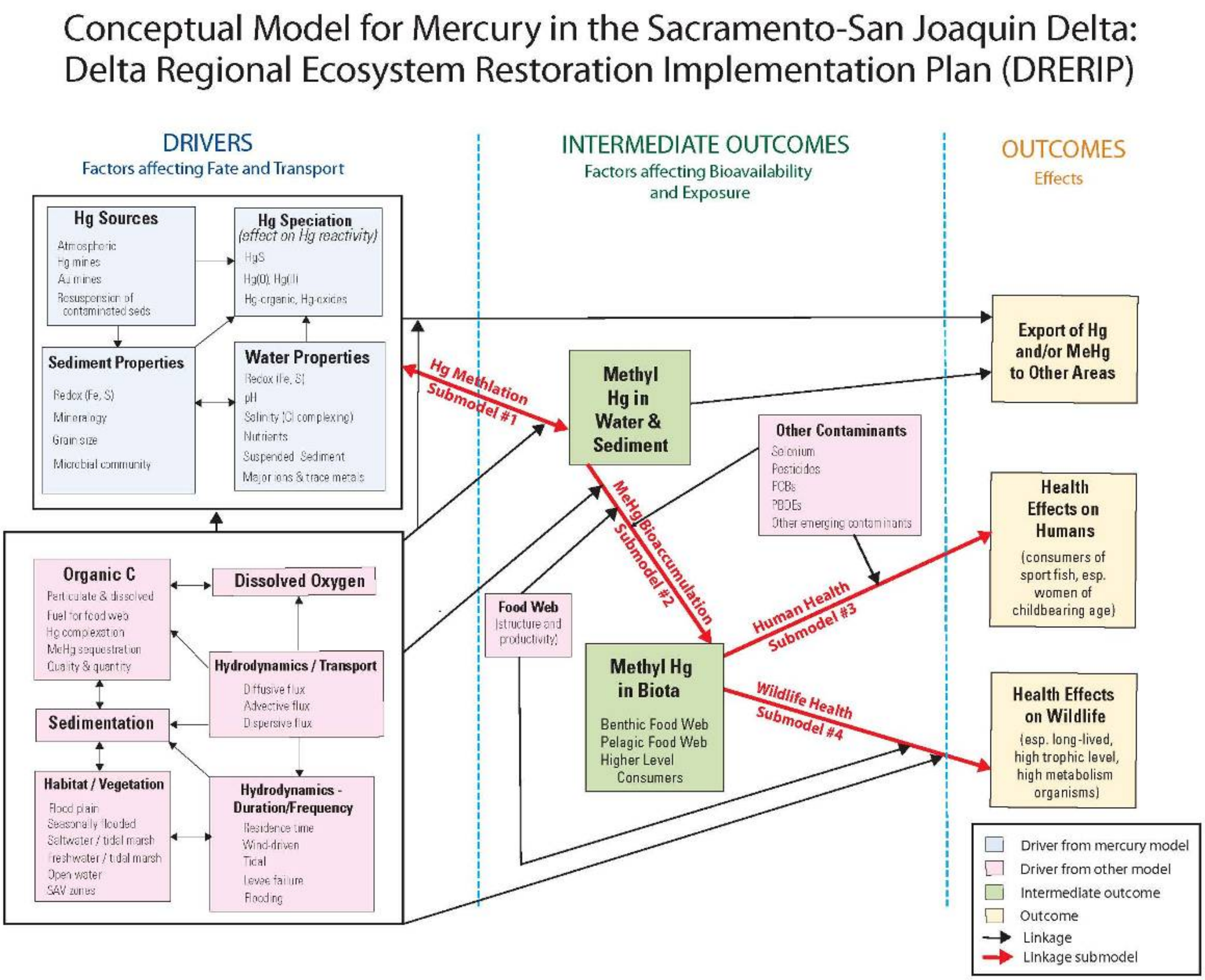
DRERIP Background

MeHg is designated as a priority pollutant within the Sacramento-San Joaquin Delta and a TMDL to reduce loads is in final stages of development by the Central Valley Regional Water Quality Control Board. The DRERIP mercury conceptual model (http://www.science.calwater.ca.gov/pdf/drerip/DRERIP_mercury_conceptual_model_final_012408.pdf, DRERIP-MCM, Alpers et al. 2008) was developed in order to evaluate options for restoration actions within the watershed, historically contaminated with Hg from gold mining activities. Tests of the DRERIP-MCM are sought by the CALFED-ERP to determine the feasibility and power of potential management actions to limit human and wildlife health impacts from Hg exposure. As seen in Figure 1, the DRERIP-MCM is comprised of four submodels (red arrows) that drive final and intermediate outcomes of concern:

1) Mercury methylation
2) Methylmercury bioaccumulation
3) Human health
4) Wildlife Health

Each of these submodels is sensitive to a unique set of driving factors, and each contributes in variable degrees to the final outcomes. Two immediate outcomes of Hg(II)-methylation and MeHg bioaccumulation (submodels 1 and 2) are MeHg concentrations in key matrices: 1) water and sediment and 2) biota. As a monitoring tool, these matrix concentrations can be compared between treatments, sites and times to evaluate the relative influence of different conditions. Except for sediment, these water and fish concentrations are the focus of the current EPA-funded study. We suggest that adding a few more analyses to the monitoring tool box would make better use of the explicit experimental conditions being supported by EPA-funds in the Cosumnes River Preserve.

Figure 1. Conceptual model for mercury in the Sacramento-San Joaquin Delta: Delta Regional Ecosystem Restoration Implementation Plan (DRERIP-MCM). Taken from Alpers et al (2008).

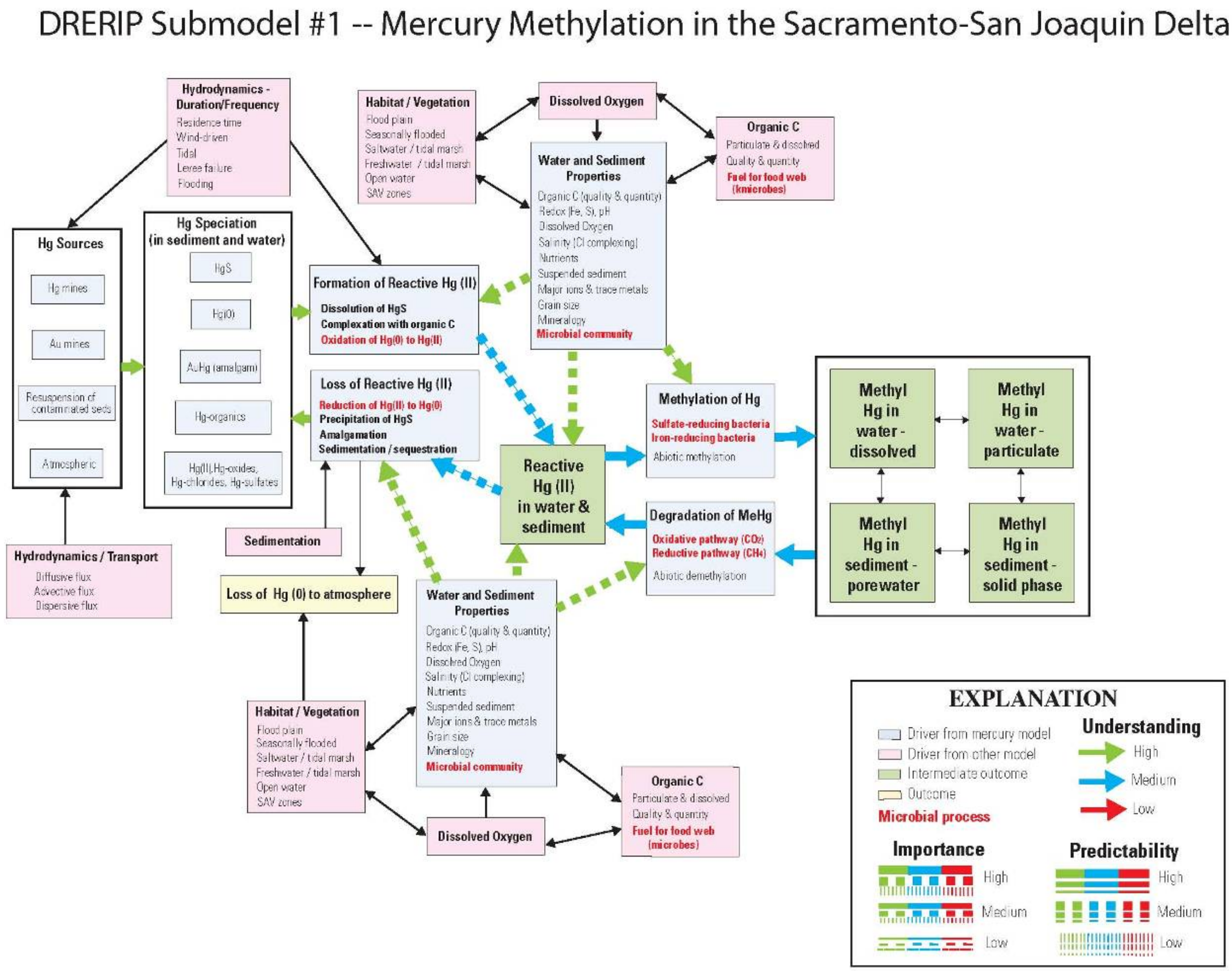


Mercury Methylation

The first submodel for the DRERIP-MCM is Hg(II)-methylation. Biotic mercury exposure is enhanced strongly by Hg(II)-methylation, the conversion of 'bioavailable' inorganic Hg(II) into the more protein-adherent and toxic MeHg. All of the drivers listed in Figure 1 are capable of playing a role in the Hg(II)-methylation submodel, but the relative importance of each driver will vary between habitats and seasonal or yearly conditions. The many edaphic drivers listed in the first column can be distinguished as those more directly related to r Hg(II) availability (blue squares), and those more directly related to microbial methylation of available Hg(II) (pink squares).

Figure 2 illustrates DRERIP-MCM in detail, and further identifies these drivers in terms of their relative importance and predictability. The importance of organic carbon is paramount in the model, influencing speciation, partitioning, and microbial activity. These patterns were reinforced in the recent Yolo Bypass Wildlife Area study where strong relationships were demonstrated between MeHg and carbon dynamics at seasonal and diel timescales (Windham-Myers et al., 2010a).

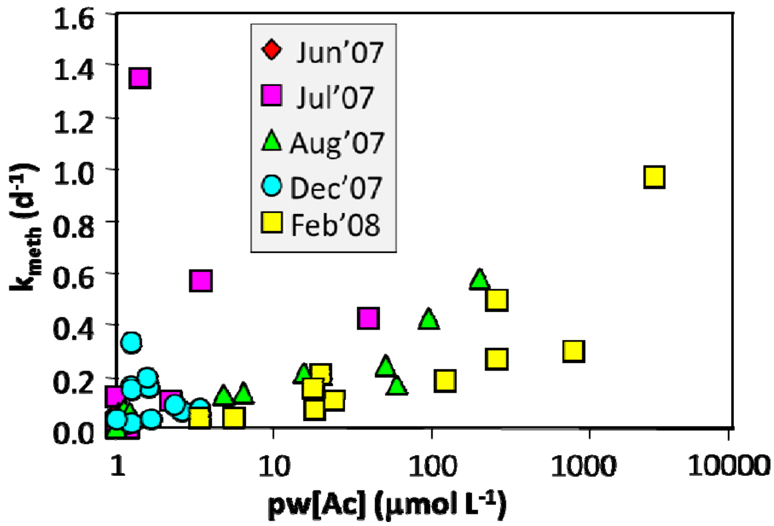
Figure 2. DRERIP Submodel #1: Mercury Methylation.



This importance of organic carbon was found to be particularly important to methylation rates among wetlands in the Yolo Bypass, as described in Windham-Myers et al. (2010a). Net rates of carbon accumulation (net primary productivity, NPP) in the Yolo Bypass rice fields during the growing season were among the highest on observed in literature (20-30 g_{dw} m^{-2} d^{-1}). This harvest-based estimate of NPP does not fully account for all carbon fixed through photosynthesis (Gross Primary Productivity, GPP), a large fraction of which may be lost belowground through fermentative respiration as well as leaching and exudation from tissues. From 20-35% of the calculated NPP was belowground, and was correlated with porewater pools of dissolved organic carbon (DOC; R=.68) and specifically, a labile, low-molecular-weight fraction of that DOC, acetate (R=0.82). Because of its relative stability and origins from fermentation products favored by anaerobic bacteria, porewater acetate, a volatile fatty acid and fermentative endproduct, was used as an index of labile carbon availability for anaerobic bacteria in wetlands.

When compared with indices of algal abundance (benthic microalgae, surface water chlorophyll-a) across field experiments and seasonal and site comparisons, plant exudates and litter appeared to be dominant drivers of porewater acetate during the growing season. Devegetation experiments showed a 64-99% decrease in porewater acetate concentrations over 3 months with the loss of aboveground photosynthetic inputs (Windham-Myers et al. 2009). During the winter flooding season, decomposing litter pools were highly correlated with porewater acetate (R=0.71), and thus suggested to be the dominant source of labile carbon in winter. These surface sediment acetate concentrations were among the strongest predictors of Hg(II)-methylation between fields at the peak of the growing season (August, r^2 = 0.39) and during winter flooding (February, r^2 = 0.42).

Figure 3. Porewater acetate concentrations vs. microbial Hg(II)-methylation rate constants (k_{meth}), within agricultural and managed wetlands of the Yolo Bypass (Windham-Myers et al. 2010a)



Another notable finding of the Yolo Bypass study referred to above (Windham-Myers et al. 2010a) is the evidence of iron-reducing bacteria as the dominant microbial community responsible for methylating sediment Hg(II). As such, oxidized iron (Fe(III)) was highly available in all field and seasonally flooded wetlands, suggesting that the methylation rates for Fe(III)-reducing bacteria were limited primarily by labile carbon supply. We also note that CALFED-funded studies on the Cosumnes River Floodplain (*Juncus*-dominated) from 2006 indicate a strong effect of devegetation on carbon supply, and a corresponding decrease in methylmercury production and sediment concentrations (Marvin-DiPasquale et al. 2007; Windham et al. 2009). Further, methylmercury responses to amendment experiments performed on Yolo Bypass sediments varied strongly between sites and replicates for sulfate, sulfide, ferrous iron, and ferric iron additions. Importantly, the only treatment that consistently stimulated of Hg(II)-methylation in laboratory incubations was the addition of porewater acetate (Marvin-DiPasquale et al. 2009). Thus, there is substantial evidence to suggest that carbon management – via field operations or water management – can be a successful mechanism to reduce methylation rates of sediment mercury pools.

Management Options

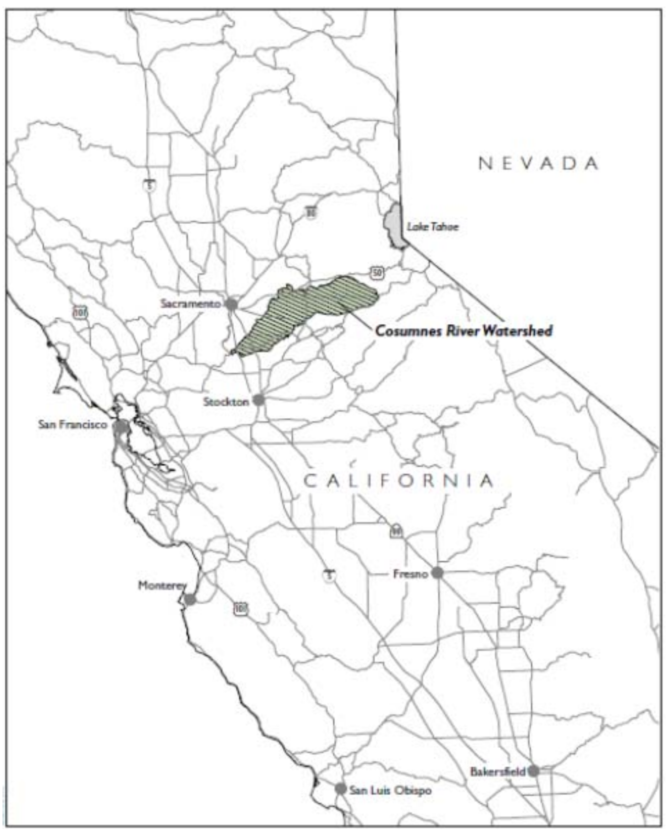
Although the Coast and Sierra Range tributaries are the principle sources of inorganic Hg to the Delta, controlling inorganic Hg loading alone appears to be inadequate to reduce MeHg concentrations to target levels (Alpers et al. 2008). Methylmercury production is known to be elevated in wetland habitats, where unique biogeochemical properties facilitate the conversion of Hg(II) to MeHg, the more toxic form to humans and wildlife. Methylmercury production is particularly common in seasonally-flooded wetlands and rice fields which undergo a sequence of wetting and drying that cyclically reduces and oxidizes sediments. This cyclical process both provides the needed fuel and electron acceptors for microbes (during oxidizing conditions; dry periods) as well as conditions to make MeHg (during reducing conditions; inundation periods). The Cosumnes watershed is comprised of an extensive network of wetlands which likely contributes substantially to the loading of MeHg to the Delta. Moreover, there are plans to substantially increase the wetland acreage in the Cosumnes watershed which could further enhance MeHg loading to the Delta.

The two most practical approaches to reducing MeHg loading into the Delta from wetlands in the Cosumnes watershed are to: 1) reduce the flow of water coming from wetlands, or 2) reduce the concentrations of MeHg in outflowing water. Since much of the water flow in the watershed is unregulated, and the ecological integrity of the wetlands in the region relies on adequate water flow, the first approach is not logistically feasible. However, reducing MeHg production and concentrations within Cosumnes wetlands could substantially reduce loads into the Delta. Recent research in the Central Valley has identified factors that are associated with MeHg production (Marvin-DiPasquale et al. 2007, Marvin-DiPasquale et al. 2009), and can be actively managed to limit MeHg production. Additionally, some wetland habitat types, such as perennial wetlands may produce less MeHg than more seasonal wetlands. Therefore, this project will use water and land management practices to minimize MeHg production and export to the Delta.

3. Approach and Scope of Work

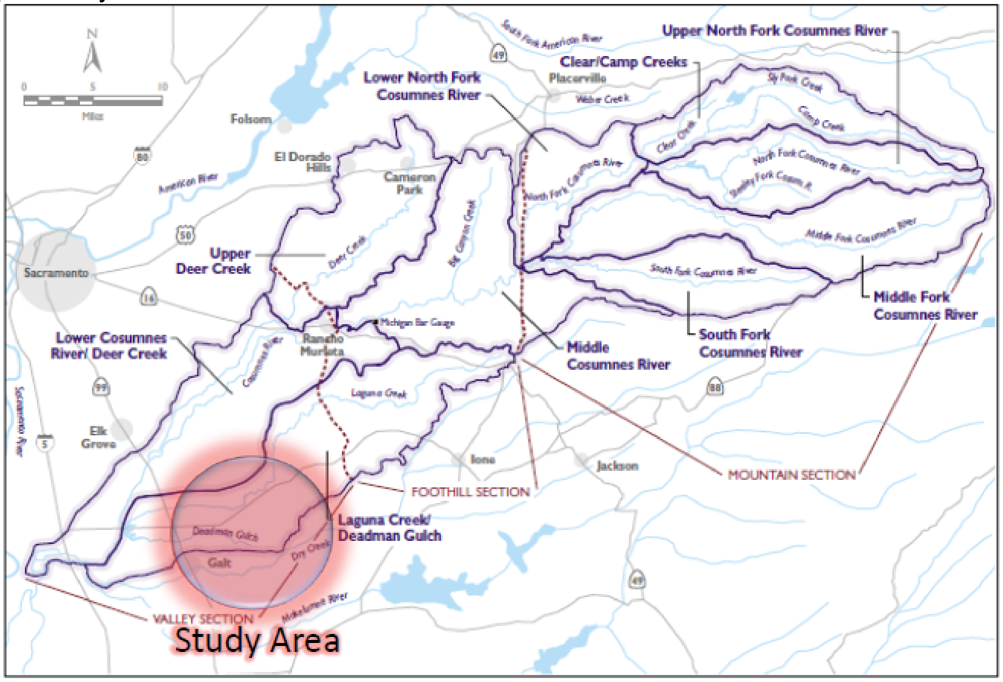
Location and Context
The Cosumnes River Watershed drains 1989 km^2 of the western Sierra Nevada (Figure 1). The lower portion of the watershed is dominated by the Cosumnes River Preserve, which encompasses more than 46,000 acres of wetland, upland, and agricultural lands. The Preserve is owned by a consortium of seven land-owning Partners (Nature Conservancy, Bureau of Land Management, CA Dept of Fish and Game, Sacramento County, Dept of Water Resources, Ducks Unlimited, and the California State Lands Commission), and is managed by the Bureau of Land Management for the protection of a continuous riparian corridor extending from the Cosumnes headwaters to the Delta. The preserve is comprised of a mosaic of habitats that include floodplains, vernal pool grasslands, seasonal and permanent wetlands, oak woodlands, and rice agriculture. This diversity of habitats supports an abundance of wildlife (including several special status species, such as Greater sandhill cranes, Giant garter snake, and Western pond turtle) and native fish species. Previous mining activities in the upper portion of the watershed have resulted in extensive Hg contamination within the Cosumnes River and the fluvial plain of the lower watershed. The abundance of wetlands in these areas facilitates MeHg production (Marvin-DiPasquale et al. 2007), resulting in elevated discharge to the Delta. However, the floodplains and wetlands within the Cosumnes watershed are critical rearing habitat for native fishes, migratory birds, and important to ecosystem function. Therefore it is critical to protect and expand these habitats while reducing MeHg export. Further, rice agriculture is an economically important crop in California, nationally and globally. At over 0.5M acres, rice agriculture represents over 10% of California's agricultural crop acreage, and is roughly equal in acreage to naturally vegetated wetlands in the state. Developing a mechanistic understanding of the best management practices for limiting MeHg exposure from this dominant land use will have a wide range of benefits within the state and beyond.

Map 1. Location of Cosumnes River Watershed draining into San Joaquin River, California.



This project will encompass more than 600 acres of rice fields, seasonal wetlands, and permanent wetlands, as well as slough channels that either provide water, or receive drainage from managed wetlands, and several locations within the Cosumnes River itself (Figure 2, 3). These areas lie within a region that was identified in the Central Valley MeHg TMDL (http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/) as a hotspot for MeHg contamination and ultimate discharge into the Delta. Moreover, there are ongoing and planned efforts to restore additional wetland habitats in Cosumnes watershed, which may further increase MeHg to the Delta. The Sacramento-San Joaquin Delta MeHg TMDL calls for a 57-64% reduction in loads from the Cosumnes watershed, which will require implementing land and water management practices that reduce MeHg loading rates. Load reductions may be met by strategically targeting restoration efforts towards those wetlands habitats that have lower MeHg production rates, and by managing rice agriculture to export less MeHg.

Map 2. Detailed Map of study location within Cosumnes River Watershed.



<u>Tasks</u>

The current EPA-funded Cosumnes River project defines three main tasks:

Task 1 – Field management to reduce organic matter concentrations (U.S. Bureau of Land Management)[1]

Task 2 – Determination of biosentinel fish Hg concentrations in response to management (USGS Western Ecological Research Center)[2]

Task 3 – Determination of aqueous MeHg concentrations in response to management (Moss Landing Marine Laboratories)[3]

By focusing only on monitored outcomes of MeHg concentrations in fish and surface water, we suggest that any effect (or lack thereof) of agriculture / wetland management on MeHg exposure will be difficult to decipher without the following additional information:

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[1] Text from EPA 319(h) Scope of Work: *Manage water levels in wetlands and post-rice harvest stubble in rice fields*. Organic matter reduction is being performed by farmers leasing BLM lands within the Cosumnes River Preserve. These management costs, and contingency costs for potential economic losses, represent more than ½ of the federal funds allocated to this project. Three spring-flooded wetlands will be inundated with water in May 2011 and 2012, and drained in September 2011 and 2012. Three fall-flooded wetlands will be inundated in November 2010, and water will be held until September 2012. Experimental rice harvest will include (1) mowing rice straw to remain in fields, (2) tilling rice straw into the fields, and (3) bailing rice straw and removing it from fields. Three fields will be used for each of the above treatments, and straw management will occur approximately in September 2010 and 2011. Progress for this task is being documented through quarterly and annual reports to the EPA.

[2] Text from EPA 319(h) Scope of Work Task 2a: *Determine methylmercury concentrations in inflowing and outflowing water from wetlands and rice fields*. One month after initial flood-up (approximately May), water will be sampled following EPA-approved clean hands-dirty hands method at the inlet and outlet of each wetland and rice field. Water sampling will also occur on the main-stem of the Cosumnes River at one site upstream and one site downstream of the Cosumnes River. Additionally, several slough locations will be sampled for water methylmercury concentrations. Slough sites will be a combination of irrigation source water and receiving water. Water sampling will occur at all locations on three occasions per year during the growing season (May through September), and from all locations except rice fields on three occasions during the winter between 2011 and 2012 growing seasons. In total, there will be six sampling events from 48 locations, and 3 sampling events from 30 locations, resulting in a total of 126 water samples being collected and analyzed for methylmercury through the duration of this project

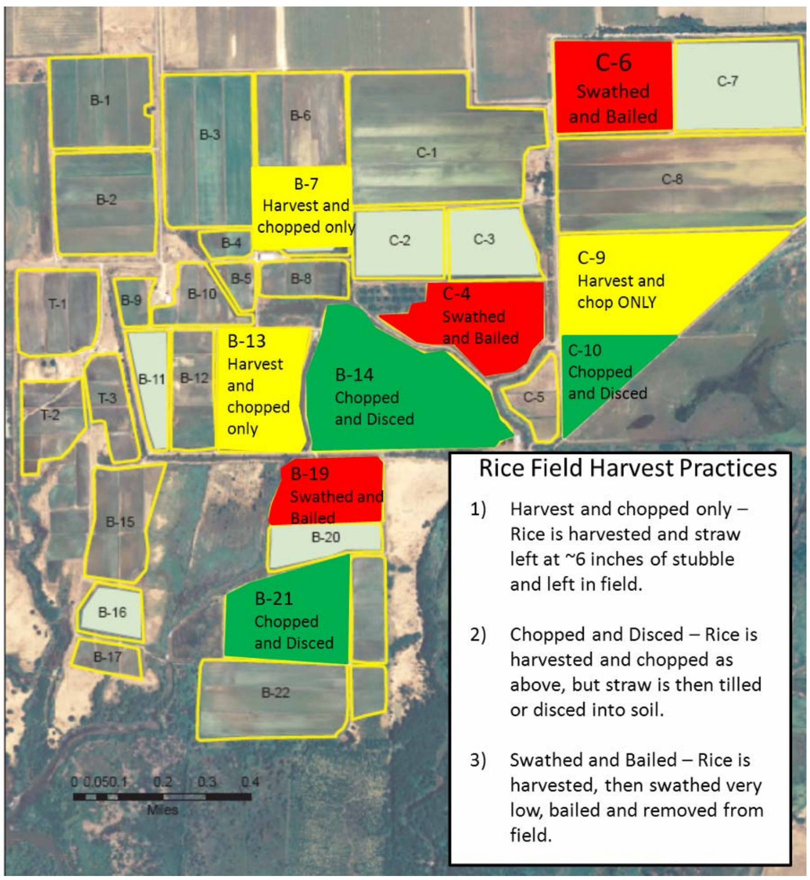
[3] Text from EPA 319(h) Scope of Work Task 2b: *Determine mercury bioaccumulation in biosentinel fish from wetlands and rice fields*. Western mosquitofish (*Gambusia affinis*) will be acquired from the Sacramento-Yolo County Vector Control District rearing ponds, and placed into 450 liter caged enclosures following methods similar to Ackerman and Eagles-Smith, 2010 at all 48 locations where water sampling will occur. Prior to placement in enclosures, fish will be measured to the nearest 1 mm and weighed to the nearest 0.01 g. Fish will be randomly placed in various cages, with a density of up to 30 individual per enclosure. Enclosures will be placed in wetlands within 30 days of spring/summer inundation and held in the wetlands for 30 or 60 days. When enclosures are removed from the fields, each fish will again be weighed and measured, then sacrificed and placed in individually-labeled containers prior to mercury analysis. Each fish will be analyzed for total mercury. It has been well-documented that approximately 90-95% of all mercury in mosquitofish is in the methylmercury form, therefore considerable cost savings can be realized by analyzing for total mercury. An additional 30 to 50 fish per year will be analyzed prior to placement of enclosures in wetlands to provide an estimate of baseline levels of mercury in fish at introduction.

1) **documentation and quantification of actual changes in the organic matter** availability due to field management (which is the presumed dominant effect of the field manipulations)
2) **documentation and quantification of historic and manipulative variability** between fields in
   a. initial sediment conditions (e.g. THg, MeHg, grainsize, initial organic matter) AND
   b. collateral effects of management (e.g. oxidation-reduction status, pH, temperature)
3) **quantification of relative rates of evapoconcentration**, considering that fields are different sizes and with different orientations along the Cosumnes River floodplain.

Without these supporting data sets, interpretation of the experimental field study results will be difficult in all cases but one. For clarification, the only "interpretable" data from the current design will be if field management exerts a dominant control within all three of the replicate fields observed, thus showing a discrete statistical effect based solely on management. As seen in Figure 3, field management is randomly distributed across the field matrix, to minimize confounding effects on treatment effects. If this field management is successful, we will still need to document variability among fields and management actions to interpret and extrapolate the results for implementing BMPs. Data from the Yolo Bypass Wildlife Area study on management, hydrologic and soil differences between fields were key to determining net effects of crop type on MeHg dynamics.

Thus, we seek to enhance this study by adding a subset of measurements that allow interpretation of key mechanisms by which Hg(II)-methylation, MeHg bioaccumulation and export are influenced by field management. The proposed 8 tasks described below will provide key background monitoring data (Tasks 1-6) upon which to statistically compare degrees of response between fields (continuous statistical tests, e.g. correlations, regressions; Tasks 7-8). This will allow us to investigate the sensitivity of the DRERIP-MCM to management actions and aid in interpretation of the aqueous and fish Hg concentration data. With n=3 for replicate treatments, it would be prudent and scientifically more interpretable if these supporting datasets were also collected.

Map 3. Field Management Layout for Cosumnes River Preserve.



Study Design

The six treatments of the field design can be summarized as follows:

Managed wetlands:
1) Winter-flooded wetlands (n=3)
2) Spring-flooded wetlands (n=3)
3) Perennially flooded wetlands (n=3)

Rice fields:
4) Rice straw left in fields (n=3) CONTROL
5) Rice straw tilled into field (n=3)
6) Rice straw removed (bailed) (n=3)

While the larger project team will be mobilized in May 2011, we will engage this portion of the project at the beginning of the 2011 harvest (~September), after contracting. After that point, sampling will be consistent and coordinated among the team with the following estimated event dates:

- September 2011 (harvest)
- February 2012 (midwinter flooding)
- May 2012 (floodup of rice and seasonal wetlands)
- September 2012 (harvest)

All 18 treatment fields will be evaluated for the tasks described below. For access and coordination with the biota and water sampling design, we will focus sediment and plant sampling near the outlets using replicate plots representative of the larger field treatment. For each sampling date, and for each site, the USGS Menlo Park team will collect the following supplementary data. In general, this will correspond to 216 samples for each metric described below. The methods summarized below are described within the Yolo Bypass Wildlife Area Final report, available on line at:

http://swrcb2.swrcb.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/other_technical_reports/ybwa_hg_final_rpt.pdf

More method details are also available in Windham-Myers et al. (2010b) and within the Quality Assurance Performance Plan (Windham-Myers et al. 2007, available upon request from Janis Cooke, CVRWQCB, jcooke@waterboards.ca.gov).

Tasks

1. Document and quantify **sediment and plant-based organic matter** availability, source and pools in response to field management
   a. **Porewater Dissolved Organic Carbon and Volatile Fatty Acids:**
      i. Replicate (n=3) samples of surficial porewater (5cm deep) will be drawn through acid-clean teflon sippers via syringe, 5 ml will be filtered (0.45 μm) into evacuated, combusted serum bottles, and frozen until Shimadzu-HPLC analysis for volatile fatty acid concentrations including acetate, lactate and malate.
      ii. Replicate (n=3) samples of surficial porewater, also 5ml, will be filtered into evacuated combusted serum vials, chilled and sent to CAWSC, for optical absorbance properties and dissolved organic carbon concentration (DOC) with a Shimadzu TOC-5000a analyzer. (CAWSC subcontract)
   b. **Plant organic matter inputs:**
      i. Replicate (n=3) field samples of above and belowground tissue will be harvested in 0.25m^2 quadrats, and assessed for stem density, total mass, species, and C:N concentration (as an index of decomposability). Live belowground tissues will be assessed for root density and surface area using a vital stain and imaging software (WinRhizo).
      ii. In September 2011 and 2012, gross primary productivity (photosynthesis), stomatal conductance, transpiration, and fluorescence stress will be assessed by a LiCor 6400 photosynthesis analyzer in a separate field trip for the dominant plant species in each field. GPP will be scaled to calculate net carbon fixation on an areal basis (gC m^{-2} d^{-1}), for estimates of fermentative and oxidative respiration in comparison with NPP and acetate pools measured by vegetation harvest.
   c. **Surface Litter:** Replicate (n=3) field collections of sediment surface litter will be collected and analyzed for mass and species. Estimates of decay rates will be assessed with in-lab incubations of fresh tissues collected in September 2011 and 2012, respectively.
2. Document **surface water organic matter** availability, source, and pools
   a. **Particulate Organic Matter**: Four 250ml splits of surface water, to be collected by CAWSC, will be kept chilled and dark until filtered through replicate, pre-weighed combusted glass fiber filters (nominally 0.7

μm). The particle-laden filters will then be freezedried and weighed for total suspended solids (TSS). Two will then be combusted at 450C and reweighed for % organic.
   b. **Carbon:Nitrogen Ratio**: The relative fraction of algal and macrophyte sources to the surface waterpool of organic carbon will be assessed by CHNS analysis of the C:N ratio of the particulate material on the remaining two filters from the POC analysis described above.
   c. **Dissolved Organic Matter**: As CAWSC processes field samples to be sent to M. Stephenson (MLML) for MeHg analysis, selected samples will be assessed for field fluorescent-optical properties and DOC concentrations to interpret predictive relationships for MeHg concentrations (Bergamaschi et al. in press)
3. Document **sediment variability** between fields and collateral effects of management actions
   a. Replicate (n=3) field samples of surface **sediment** (0-2cm depth) will be collected and homogenized for:
      i. **total mercury** concentration (THg), field-frozen, assayed with BrCl digestion and CVAFS analysis
      ii. **reactive mercury** concentration ($Hg(II)_R$), field-frozen
      iii. **grainsize** (% silt), via wet sieving of sediment slurry through 64um mesh
      iv. **organic content** (%loss on ignition), via dry weight difference post-combustion
      v. **oxidation-reduction potential** (ORP), in field with calibrated platinum probe
      vi. **pH**, in field with calibrated $Ag/AgCl_2$ probe
      vii. **temperature**, in field, directly in surface water and sediment
4. Document **sediment and porewater MeHg** responses to management actions
   a. Replicate (n=3) field samples of surface sediment (0-2cm depth) will be collected, homogenized, and field frozen for laboratory analysis of methylmercury concentration, as assayed by KOH:methanol extraction followed by CVAFS analysis on a MERX automated methylmercury analyzer
   b. Replicate (n=3) samples of surficial porewater (5cm deep) will be drawn through acid-clean teflon sippers via syringe, filtered (0.45 μm) into evacuated, combusted serum bottles, and assayed by distillation followed by CVAFS analysis on a MERX automated methylmercury analyser
5. Document **MeHg accumulation** in seeds of rice and native vegetation
   a. At least 50g of seeds (wet weight) will be collected from each field just prior to harvest, rinsed with deionized water and frozen until analysis. Rice seeds will be separated into husk and grain. Seeds will be freeze-dried, ground, and analyzed for total mercury and methylmercury concentrations using the methods described above for sediment analysis.
6. Document **evapoconcentration** and DOC relationships between inlet and outlet to estimate MeHg export
   a. A 10ml field split of each of surface water sample collected by CAWSC for MeHg analysis by MLML will be kept chilled, filtered (0.45 μm) and returned to the CAWSC for analysis of Cl by ion-chromatograph and DOC by TOC analysis. Cl concentrations at inlets and outlets of each field will be used as a conservative trace to calculate a simple metric of evapoconcentration across fields. (CAWSC subcontract)
7. **Statistical integration with fish and aqueous MeHg concentrations**:
   a. **Discrete statistical analyses** will be performed using repeated measures ANOVAs or non-parametric direct comparisons where appropriate to assess variability among responses for:
      i. Field types (agricultural vs. natural)
      ii. Management actions
         1. Disced vs. tilled vs. control conditions for rice fields
         2. Perennial vs. spring-flooding vs. natural flooding for naturally vegetated wetlands
   b. **Continuous statistical analyses** will be performed
8. **Assessment of the importance and predictability of DRERIP linkages** for agricultural and managed wetlands in the Central Valley
   a. The relative importance and predictability of drivers will be assessed for Submodel #1 (Mercury Methylation), for agricultural and managed wetlands in the Central Valley. Multiple regression tools will be employed to separate the dominant seasonal and spatial drivers for MeHg production. The data will also provide input for incorporation of rice-seed and plant-tissue based diets into the model for both human and wildlife health (Submodels #3 and #4).

Schedule

The EPA-funded project is already underway, having begun rice straw field manipulations in Fall 2010. Fish and water sampling is expected to begin in May 2011. We request a start date of September 2011, in order to coordinate the first harvest event. From that point, our sampling will occur only once seasonally, whereas water collection for MeHg analysis will occur monthly. The schedule, shown in Table 1, incorporates the 8 tasks represented in this proposal within the context of the tasks identified in the EPA-funded project. Each field event (n=4) will require 3-4 field days. Summer 2011 and 2012 will require selected daily field trips by Windham-Myers to document gross primary productivity (total C fixed) by macrophytes (rice, bulrush, *Juncus*) at the peak of the growing season (August-September).

Table 1. Proposed timeline of events for Tasks 1-8, in coordination with EPA-funded fish and water sampling.

Task	2011		2012				2013			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
EPA Project Structure:										
Rice Growing										
Water Management										
Organic Matter reduction										
Water Sampling										
Fish Sampling										
Proposed Project (Supplemental)										
1. Organic matter (plant, porewater, litter)										
2. Organic matter (surface water)										
3. Sediment state variables										
4. Sediment and porewater MeHg										
5. Seed MeHg										
6. Estimate evapoconcentration										
7. Stastical Analyses										
8. DRERIP integration										
Annual Report										
Final Report										

4. Deliverables

Upon execution of the contract, quarterly updates will be provided to DFG staff. For this 2-year study, we agree to submit an annual report (~September 2012) and a final report (~2013) in accordance with state-defined submission guidelines. Data will be provided in SWAMP-compatible files, and in accordance with QAPP guidelines as developed for the SWRCB-Yolo Bypass project (available upon request). At least 2 lead-authored publications will be forthcoming in applied science journals (e.g. Ecological Applications, Environmental Science and Technology, Bioscience). In coordination with colleagues on the EPA-funded project, outreach products and public meetings to share results are scheduled for April-September 2013. Project team members will also participate in monthly or semi-monthly Delta Tributaries Mercury Council meetings.

5. Feasibility

Site selection was based upon the ability to independently move water into and out of wetlands. We selected sites that discharge water directly into receiving sloughs to allow us to evaluate the impact of our implementation on water quality within the Cosumnes River and loadings to the Delta. All work will be conducted on Federal Land (Bureau of Land Management), which is the lead agency on the EPA-funded proposal. Therefore, we do not require a process to obtain landowner agreement. Figure 3 identifies the rice fields and wetlands that will be utilized in this study, and harvest treatments have been randomly assigned to each rice field.

As owner and manager of the lands used in this study, BLM will evaluate the results and potentially implement any suitable Best Management Practices that successfully reduce MeHg production while maintaining appropriate habitat conditions for targeted wildlife. Additionally, the results generated by this project will be applicable to wetlands and rice fields throughout the Central Valley and globally, due to the mechanistic DRERIP structure. By communicating our findings to a broad range of stakeholders (scientists, land managers, farmers, etc.) through publications and outreach, such as public meetings and via the Delta Tributaries Mercury Council, we will be in a position to support the implementation of successful practices throughout the region. This project is currently ready to proceed. Because it will occur on Federal Land, and primarily involves data sampling, with no construction, it does not require CEQA analysis. However a NEPA analysis has been completed. Scientific collecting permits are authorized for the caged fish studies. Field manipulation has already begun on these fields (October-November 2010). All permits and agreements are in hand and active for the tasks listed here and the larger project. This proposal seeks only to add additional mechanistic sampling to the study to enhance the applicability of its findings within and beyond the Cosumnes River Preserve.

6. Relevance to the CALFED ERP

The proposed research is highly relevant to CALFED goals of improving ecosystem quality and water quality. In particular the ERP seeks to achieve objectives for ecosystem restoration that "improve or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed and **eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people**". Better understanding of uncertainties and linkages within the DRERIP models is a primary focus of this PSP. In particular, this research addresses concerns about Hg(II)-methylation in shallow-water habitat, a preferred restoration action to promote native species recovery. The current body of research represented in the DRERIP model, as well as recent studies by myself colleagues, has demonstrated a significant risk of these habitats for Hg(II)-methylation, biotic exposure, and export to the larger delta ecosystem. While the current EPA-funded research will test whether fish and water MeHg concentrations respond to field manipulations, the study does not mechanistically test the DRERIP model for sensitivity to these management actions.

We propose to add a subset of key indices by which to monitor and evaluate the influence of proposed management practices on MeHg control. By clarifying initial conditions, collateral effects, and key linkages from management actions to environmental impact, these data will allow the PI's and managers to answer the following broad and basic questions:

1) **Why** does a given management action influence or have no effect on MeHg in biota?
2) To what extent are water concentrations (of all constituents) a function of evapotranspiration? This will enable our ability to infer the relative effect of treatments on actual MeHg export (loading).
3) By altering carbon dynamics, what other collateral influences might these manipulations have on ecological indices such as biogeochemistry? Future studies may then use this data to interpret management effects on such processes as methane production, water use, and migratory bird habitat quality, to name just a few.

Further, an important finding in the aforementioned Yolo Bypass Wildlife Area study was an apparent tradeoff between MeHg export and *in situ* MeHg bioaccumulation – while holding water on rice fields for longer periods of time permitted a reduction in exported MeHg loads, it also may have promoted MeHg bioaccumulation in resident fish. With many endangered and migrating species visiting rice fields in the central valley through the fall and winter seasons, ERP goals can be strongly linked between species protection and water and carbon management.

7. <u>Expected quantitative results (project summary)</u>:

The ultimate goals of this project are to test several logistically feasible management strategies for altering wetland management and farming practices to reduce MeHg production and discharge to the Delta. This project is expected to result in reduced MeHg production within, and export from, wetlands where organic matter reduction practices are implemented. We base our expectations on mechanisms observed in the Yolo Bypass Wildlife Area study, and DRERIP-predicted mechanisms. The success of these management practices for TMDL goals will be made by examining a suite of changes in Hg dynamics:

- We expect a lower rate of MeHg bioaccumulation in biosentinel fish in disced and bailed fields and in spring-flooded and perennial wetlands.
- We expect lower aqueous MeHg concentrations in the surface water in disced and bailed fields and perennial wetlands. Aqueous MeHg loads (as calculated with a Cl-balanced water budget) may be reduced by ~30%.
- We expect lower concentration of MeHg in both sediment porewater and in rice tissues (especially seeds).

Mechanistically, the controlling factors and <u>degree</u> of success will be determined by comparing results of management actions on productivity and biogeochemical processes within fields.

- We expect lower pool sizes of sediment organic matter in disced and bailed fields, and permanently flooded fields. For example, porewater acetate concentrations may be reduced by 50-80%.
- We expect that any reduction in organic matter in sediment and surface water will be proportional to an observed reduction in MeHg concentrations in surface water, porewater, sediment, fish and plant tissue.

Considering other feedbacks in this managed system, collateral effects may be seen in key biogeochemical state variables such as vegetation structure, sediment profiles (e.g. organic matter, mercury, nutrients), temperature, redox potential, etc.. With these proposed management actions, some possible negative effects on management goals include longer-term changes in rice yield (current output is roughly 3500 lbs per acre), methane production, reduced visitation by sandhill cranes and other migrating birds, and both vegetation shifts and increased water usage by the establishment of permanent wetlands. This study focuses only practices to limit methylmercury production and export. Any best management practice must meet the goals of the Cosumnes River Preserve landuses (e.g Cosumnes River Preserve Management Plan, 2008). For example, sandhill crane visitation is enhanced by shallowly-flooded conditions (ideally 8" water depth). Follow-up studies are needed to address whether crane visitation or habitat quality (invertebrate abundance, MeHg concentration) is compromised by the management actions proposed and tested in this study.

Despite the small footprint of implementation to only a subset of wetlands within the Cosumnes River Preserve, we expect our overall load reduction to be 3%-5% of the reductions called for from the Cosumnes River subarea in the Central ValleyMeHg TMDL. However, if these reductions are realized and BMPs are developed via this demonstration project, there is substantial potential for significantly reduction of MeHg loads into the Delta in the future. Specifically, with over 220,000 acres of rice planted in the Central Valley, organic matter reduction management applied on a large scale could result in substantial progress toward meeting MeHg loading goals stated in the TMDL for the Delta.

The Sacramento-San Joaquin River Delta MeHg TMDL estimates that MeHg from wetlands makes up 16% of total sources to the Delta, contributing approximately 767 g of MeHg per year. With 20,743 acres of wetland habitat within the

Delta, this results in a loading of approximately 0.038 g MeHg/acre/year. Using our estimates described above for organic matter removal and methylmercury reduction, we estimate that we will reduce loads from the Cosumnes River rice fields and wetlands to approximately 0.57g MeHg/year or 0.001 g MeHg/acre/year. If these methods are successful, and more broadly applied to other areas in the Central Valley, loads could be reduced by up to 30%. The cost of implementation is about $190 per acre, most of which is associated with matching funds for employing alternate harvest practices. However, future farmer subsidies may both be necessary for farmer participation as the management practices being studies also have substantial benefits to rice cultivation and already are used on an intermittent basis. This project is directly relevant to the Delta MeHg TMDL and other watershed plans that address Hg issues in the region. The Delta TMDL specifically identifies wetlands, and the Cosumnes River watershed as key sources. Additionally, the plan requires an initial phase of implementation studies to evaluate management practices that can be implemented to reduce MeHg discharge to the Delta. This project will directly link with the Delta Tributaries Mercury Council which is a component of the Sacramento River Watershed Program. Together with stakeholders, this project will leverage information and resources together into a cohesive network for management of wetlands to minimize MeHg production and export. By pooling resources with the wide group of stakeholders in the region, we will be able to apply the results of this project across the Delta to further fill data gaps necessary for TMDL implementation.

Project performance will be monitored by quantification of multiple indices of mercury cycling. We will compare Hg concentrations both within wetlands (inlet vs. outlet) and among wetlands (different harvest treatments, inundation time periods, etc). Whereas the EPA-funded water sampling will occur approximately monthly during the growing season, and at three time periods during the fall/winter between 2011/2012 seasons, the 6 field-sampling tasks described within this proposal will be performed only for key seasonal events in May, September and mid-winter (e,g. February). Caged fish will be introduced into wetlands at the start of the growing season, and allowed to accumulate MeHg for 30-60 days, after which they will be removed and analyzed for contaminants. All proposed activities are similar to those employed in recent studies funded by the Central Valley Regional Water Quality Control Board of the Yolo Bypass Wildlife Area and are covered under the QAPP developed for that project. All data generated in this study will follow SWAMP protocols and will be able to be directly integrated into existed SWAMP databases.

8. Other products and results:

This project brings together a wide variety of stakeholders and partners to address the feasibility and effectiveness of proposed management practices to limit MeHg in accordance with future TMDL guidelines. Those involved in this process include landowners in the region, natural resource agencies such as US Fish and Wildlife Service, and rice farmers that lease the land. Colleagues (see Conflict of Interest list) have already had three integrated team meetings with partners to identify critical needs, design the study for successful implementation, and discuss practical limitations and solutions. Stakeholder involvement will continue to be facilitated through several avenues. First, the project team will participate in monthly Delta Tributaries Mercury Council meetings and provide updates. This Council provides a forum for sharing knowledge and integrating approaches by interested and vested individuals throughout the Central Valley. Secondly, we will hold a public workshop at the end of the project to share the results to the greater community and for Best Management Practices Implementation. We will also hold quarterly project meetings between the project leadership and the partners to recruit input and provide updates on the status of the project.

9. Qualifications

The PI for this project will be Lisamarie Windham-Myers. Dr. Windham-Myers is a wetland biogeochemist specializing in plant-ecosystem ecology (https://profile.usgs.gov/lwindham-myers/). Her recent projects include federal- and state-funded research in wetlands throughout San Francisco Bay, with an emphasis on the role of plant processes in biogeochemical cycles, including carbon and mercury. She was a PI and the lead author of both the QAPP and the final cooperator report from the SWRCB-funded Yolo Bypass mercury study in agricultural and managed wetlands (Windham-Myers et al. 2010a). She is also a guest editor for a special issue of Science for the Total Environment entitled “Mercury Cycling in Agricultural and Managed Wetlands of the Yolo Bypass, CA” currently being submitted. She was a PI and coauthor on the recently completed CALFED study (ERP-02-P40; Marvin-DiPasquale et al. 2007) which focused directly on the Cosumnes River Floodplain. She is familiar with the land management history and vegetation types and distribution within the study area. Data from both of these studies have been included in a recently published cross-site study (Windham-Myers et al., 2009). Dr. Windham-Myers recently acquired a portable infrared-gas analyzer for analysis of photosynthetic rates and fluorescence stress, which will be useful in the context of the field measurements described above. The Marvin-DiPasquale lab has a documented record of meeting quality control standards for mercury analyses in sediment, water and plants. Porewater and surface water DOC and surface water Cl assessments are subcontracted Jacob Fleck (CAWSC). All of the aforementioned USGS staff have a history of working within rice fields and shallow-wetlands of the San Francisco-Bay Delta (http://ca.water.usgs.gov/mercury/riceFields.html).

Dr. Windham-Myers has worked closely for more than 5 years with the PI’s of the EPA-funded project referenced above. The proposed research is in direct response to needs described by project manager Harry McQuillen, and scientists Collin Eagles-Smith, Josh Ackerman, Mark Stephenson, and Jacob Fleck. Harry McQuillen will be the project manager, leading the project as the Bureau of Land Management's Cosumnes Preserve Manager. Mr. McQuillen has extensive experience manipulating water and wetland habitats on the Preserve, as well as interacting with rice farmers that lease Cosumnes River Preserve land. Mr. McQuillen also possesses a Master's degree in Wildlife Toxicology, which gives him the technical training to understand and implement wetland operations that will reduce MeHg production and loads to the Delta. The technical component of this project will be led by Dr. Collin Eagles-Smith, Dr. Josh Ackerman, and Jacob Fleck of the US Geological Survey, and Mark Stephenson and Wes Heim of Moss Landing Marine Lab. Together, we have extensive experience evaluating MeHg production bioaccumulation, export, and loading from wetlands throughout the Central Valley, including the nearby Yolo Bypass which is managed for similar habitats. Each team member brings with them substantial staff resources to manage wetlands, collect data, and oversee the project, which will ultimately contribute to its success. Dr. Josh Ackerman and Jacob Fleck of USGS and Mark Stephenson of California DFG also will hold lead roles in this project.

This project is working with multiple partners to ensure broad applicability and overall success. Partners include the Sacramento-Yolo County Mosquito and Vector Control District, the US Fish and Wildlife Service, Bureau of Land Management, California Department of Fish and Game, US Geological Survey, and the stakeholders of the Delta Tributaries Mercury Council. In addition, this project is linked with the Delta Mercury Research Consortium which is a group of landowners, managers, and scientists that are working to implement MeHg control studies throughout the Delta as outlined in the TMDL. These partners include The Nature Conservancy, California Department of Fish and Game, Ducks Unlimited, US Fish and Wildlife Service, and Westervelt Ecological Services.

10. Literature Cited

Alpers, C., Eagles-Smith, C,, Foe, C., Klasing, S., Marvin-DiPasquale, M., Slotton, D., and Windham-Myers, L. 2008. Mercury conceptual model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan. Available online at: http://science.calwater.ca.gov/pdf/drerip/DRERIP_mercury_conceptual_model_final_012408.pdf

Cosumnes River Management Plan-Final. 2008. Prepared by Kleinschmidt Associates, Grass Valley CA. Available online at: http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/folsom/plans.Par.67798.File.dat/CRP_Final_Mgmt_Plan.pdf

Bergamaschi, B. A., J. A. Fleck, B. D. Downing, E. Boss, B. Pellerin, N. K. Ganju, D. Schoellhamer, W. A. Heim, M. Stephenson, and R. Fujii, (in press). Methyl mercury dynamics in a tidal wetland quantified using in situ optical measurements. Limnology and Oceanography. Accepted Feb 2011.

Marvin-DiPasquale, M., Stewart, A.R., Fisher, N.S., Pickhardt, P., Mason, R.P., Heyes, A., and Winham-Myers, L., 2007, Evaluation Of Mercury Transformations and Trophic Transfer in the San Francisco Bay/Delta: Identifying Critical Processes for the Ecosystem Restoration Program: Final Report for Project # ERP-02-P40. Submitted to the California Bay Delta Authority (CBDA), 40 p. http://www.dfg.ca.gov/ERP/wq_mercury_2007workshop.asp

Marvin-DiPasquale, M., Alpers, C.N., and Fleck, J.A., 2009, Mercury, Methylmercury, and Other Constituents in Sediment and Water from Seasonal and Permanent Wetlands in the Cache Creek Settling Basin and Yolo Bypass, Yolo County, California, 2005−06: U.S. Geological Survey Open File Report 2009-1182, 69 p. http://pubs.usgs.gov/of/2009/1182/of2009-1182.pdf

Windham-Myers, L., M. Marvin-DiPasquale, D.P. Krabbenhoft, J.L. Agee, M.H. Cox, P. Heredia-Middleton, C. Coates, and E. Kakouros. 2009. Experimental removal of wetland emergent vegetation leads to decreased methylmercury production in surface sediments. Journal of Geophysical Research 114, G00C05, doi:10.1029/2008JG000815

Windham-Myers, L., Marvin-DiPasquale, M., Fleck, J.A., Alpers, C.N., Ackerman, J., Eagles-Smith, C., Stricker, C., Stephenson, M., Feliz, D., Gill, G., Bachand, P., Rice, A. and Kulakow, R., 2010a, Methylmercury cycling, bioaccumulation, and export from natural and agricultural wetlands in the Yolo Bypass; Cooperator Report prepared for the State Water Resources Control Board, by the U.S.G.S., CA Department of Fish and Game, Moss Landing Marine Lab, Battelle Marine Sciences, Bachand and Associates, and the Yolo Basin Foundation. September 30, 2010,266 p. http://swrcb2.swrcb.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/other_technical_reports/ybwa_hg_final_rpt.pdf

Windham-Myers, L., Marvin-DiPasquale, M.C. , Erikson, L., Agee, J.L., Kieu, L.H., Kakouros, E., and Ward, K., 2010b, Biogeochemical processes in an urban, restored wetland of San Francisco Bay, California, 2007–2009; Methods and Data for Plant, Sediment and Water Parameters: U.S. Geological Survey Open-File Report 2010-1299, 40 p. http://pubs.usgs.gov/of/2010/1299/

Section 7: Project Budget

1. **Detailed Project Budget** ***(Excel spreadsheets can be used)***

Budget			
Project Title			
			Totals
PERSONAL SERVICES			
Staff Level	**Number of Hours**	**Hourly Rate**	
GS-13	1480	$51	75480
GS-5	680	$18	12240
Subtotal			87720
Staff Benefits @ 18%			15789
TOTAL PERSONAL SERVICES			**103509**
OPERATING EXPENSES			
Description			
Subcontractor Costs – Jacob Fleck, USGS CAWSC			25000
Materials			2000
Photographic Supplies			0
Printing and Duplicating			2000
Office Supplies			0
General Expense			0
Travel and Per Diem			3600
Training			850
Add/delete line items above for work to be performed by the contractor			
Total Operating Expenses			28450
EQUIPMENT			0
SUBTOTAL			136959
OVERHEAD @ 54% (Less Equipment)			60457
GRAND TOTAL			**197,416**

2. Budget justification:

This budget represents all work to be completed during the September 2011- September 2013 2 year window. Field management has begun (as of November 2010) and collaborators will begin collection of field data starting in May 2011. We request funds to support a field assistant (GS-5) for 680 hours of data collection and processing (2011 and 2012) and the PI (GS-13, Windham-Myers) for 1480 hours of data collection, processing, analysis, synthesis, and presentation. Staff benefits are charged at 18% of salary cost. All required equipment is currently owned by or available to the PI through shared laboratories of the U.S. Geological Survey. Materials requested include laboratory supplies (e.g. tank gases, equipment maintenance) and field supplies (e.g. sampling vials, syringes, filters). Printing costs are included to support publication in a peer-reviewed journal (e.g. Environmental Science and Technology). A subcontract to the CAWSC for $25000 is included to support laboratory analysis of surface water quality (chloride, dissolved organic matter) on samples currently being collected by the CAWSC through the associated EPA 319h funds. Travel costs are calculated for 2 people based on State of CA government per-diem costs, and include seasonal 3-day fieldtrips (n=4) in 2011 and 2012. Training costs are estimated for 1-week of time for a newly hired GS-5 (B.S.- level) employee.

3. Administrative overhead:

The U.S. Geological Survey Menlo Park Cost Center charges overhead on non-federal funds at 54%, although this overhead rate is subject to change in FY2012. The subcontract to USGS CAWSC will be passed through without overhead from the Menlo Park Cost Center, and processed directly within the CAWSC.