Meeting of the Central Valley Flood Protection Board
March 22, 2013
Staff Report
Methylmercury Open Water Control Study Workplan

1.0 – ITEM

Consider approval to delegate the Executive Officer authority to sign a letter to the Central Valley Regional Water Quality Control Board (RWQCB) expressing the Board's support of the Methylmercury Control Study Workplan (Workplan) (Attachment A)

2.0 – SPONSORS

This Workplan was produced as a collaborative effort by the Open Water Workgroup (Workgroup), including the following agencies:

- Central Valley Flood Protection Board (Board)
- California Department of Water Resources (DWR)
- California State Lands Commission (CSLC)
- U.S. Army Corps of Engineers (USACE)
- U.S. Bureau of Reclamation (USBR)

The Board was included in this group because the RWQCB has identified water and land management activities under our jurisdiction which cause or contribute to elevated levels of mercury or methylmercury in the Sacramento-San Joaquin River Delta and Yolo Bypass.

3.0 – LOCATION

This Workplan encompasses open-water habitat within channels and floodplains in the Delta and Yolo Bypass (see Attachment B for Workplan details).

4.0 – WORKPLAN DESCRIPTION

The Sacramento-San Joaquin River Delta Total Maximum Daily Load (TMDL) establishes a Delta Mercury Control Program (DMCP) as a result of Basin Plan Amendment (BPA) No. R5-2010-0043. The DMCP divides the Sacramento-San Joaquin Delta (Delta) and Yolo Bypass into seven subareas, each of which is then assigned an “open water” methylmercury load allocation in the Basin Plan. Open water allocations encompass three activities: 1) water conveyance operations that may impact Delta in-channel production; 2) flood management operations that may impact MeHg production in the Yolo Bypass; and 3) regulatory or management oversight of activities proposed within open water areas. The TMDL and BPA established a series of work products and work that must be completed by specific deadlines. Submittal of this Workplan will meet the DMCP requirement to comply with the April 20, 2013 due date.

5.0 – WORKPLAN ANALYSIS

5.1 – Board Requirements

The Board was named in the BPA and TMDL (as stated in Section 2.0) as a responsible entity because of the property, easements, and regulatory authority for the purpose of regulating floodwaters and flood control features. Therefore, Board staff has participated in this collaborative effort to meet the DMCP requirements. Specific deadlines and responsibilities are outlined in Section 5.2.

5.2 –Background

Over the last few years there has been a series of events, as shown below, that led to the production of this Workplan.

- Board staff participated in an extensive stakeholder process from 2008 thru the summer of 2011
- Throughout the stakeholder process Board staff voiced objections and wrote several letters objecting to certain concepts of the BPA and TMDL (See Attachment C)

    Consistent issues raised by Board staff:

    - Upstream sources and historical problems have contributed to the current conditions and downstream mitigation alone won’t solve the problem if the upstream issues are not handled

  - Flood control is a matter of public safety, so restricting operations, maintenance, and regulatory compliance in the floodplain is a larger scale issue and out of the RWQCB's jurisdiction

- The BPA was effective as of October 20, 2011 with the Board named as a responsible agency and given allocations for open water methylmercury
- A letter from the RWQCB was sent to the Board and DWR on November 30, 2011 (see Attachment D) outlining DMCP Board requirements, expectations, and deadlines, which are outlined as follows:
  - By April 20, 2012 submit a letter stating the Board will work as part of a collaborative group (Board submitted the letter on April 10, 2012, see Attachment E)
  - By August 17, 2012 the Workgroup was requested to submit a Concept Proposal (submitted August 17, 2012, see Attachment F)
  - By **April 20, 2013 submit an Open Water Control Study Workplan** (action requested at this time to send a letter in support of the Workplan)
  - By August 20, 2013 initiate Control Study
  - By October 20, 2015 submit a Control Study Progress Report
  - By October 20, 2018 submit a Control Study Final Report

5.3 – Workplan Objectives and Structure

The objective of this workplan is to provide two working models, one for the open waters of the Delta and one for the Yolo Bypass, to examine the impact on methylmercury supply of proposed operational changes in water management and flood conveyance in the Delta and Yolo Bypass. Subject to funding, schedule or technical constraints, and if the two models can be successfully developed, an effort may be made to integrate the two models into one large-scale model. As proposed, a combination of field data and mechanistic modeling will be used. The scope of modeling will include hydrodynamics, particle transport and mercury fate and transport.

The workplan outlines two phases. The primary objectives of Phase 1 are to (a) incorporate mercury cycling and sediment processes into an existing hydrodynamic model of the Delta and create a simplified, working model for the Yolo Bypass, and (b) collect data in the Yolo Bypass to elucidate fundamental methylmercury processes under flooding events. These tools and data will be used to examine our understanding of factors governing methylmercury supply, and potentially evaluate different operational scenarios. The primary objective of Phase 2, subject to funding, is to build upon data collection needs from Phase 1 and further enhance modeling tools and datasets, if needed, to refine estimates of existing and potential future methylmercury sources and supplies to the Delta and Yolo Bypass.

5.4 – Funding Obligations

By delegating authority to the Executive Officer to sign the support letter (Attachment A) the Board is in no way obligating funds or resources to the Control Studies other than a collaborative coordination effort by Board staff to ensure Board interests are considered. There are no obligations outlined in this Workplan. The Workplan is merely a framework of what work is to be done for Phase 1 and 2 of the Control Studies. Further work is dependent upon sources of funding, as stated in the excerpts below from the Executive Summary and Section 1.1 of the Workplan, respectively.

> *"From an available funding perspective, the proposed field and laboratory experiments represent a best case scenario. Currently, the DWR is funding all TMDL required open water studies as well as DWR, TMDL related studies associated with non-point source wetland control strategies, exposure reduction, and possible dredging work. Therefore, the proposed field and laboratory experiments and scheduling responsibilities may be subject to change to accommodate all DWR TMDL funding and scheduling responsibilities within the TMDL Phase 1 study period. The Workgroup will continue to pursue other avenues of funding to supplement the DWR's funding."*

> *"…What can ultimately be accomplished will depend in large part on whether or not adequate funding can be obtained."*

5.5 – Central Valley Flood Protection Plan (CVFPP) and Flood Management and the Interaction with Water Quality

The primary message in Section 1.4 of the Workplan regarding flood management is that the responsible agencies named in the TMDL will comply with the requirements to study the issues involving methylmercury, so long as flood control and public safety is paramount. The excerpt below from Section 1.4.1 of the Workplan exemplifies this very key issue as it pertains to the Board's jurisdiction.

> *"…The Central Valley Flood Protection Plan (CVFPP) was adopted by the Central Valley Flood Protection Board (CVFPB) in June 2012 (DWR, 2012a). The Flood Plan is designed to provide conceptual guidance that will reduce the risk of flooding in the Central Valley. The guidance is designed to incorporate*

> *urban area, small community and rural agricultural flood risks. Flood mobilization of mercury laden sediments is a significant factor when describing mercury transport and distribution within a watershed. However, while these effects must be understood, in order to model mercury cycling, changes to the way that flood events are managed are unlikely to provide a feasible means of addressing elevated mercury levels because **flood control is a public safety action that takes precedence over water quality**."*

In Section 1.4.2 the Workplan discusses flood management of the Yolo Bypass and Board jurisdiction is explicitly noted as follows:

> *Changes to operation of the Yolo Bypass must be approved by the CVFPB and other appropriate authorities, if applicable. Within the Yolo Bypass, land use is restricted by easements held by the CVFPB pursuant to California Code of Regulations (CCR), Title 23 and 33 United States Code (USC) Section 408. In addition to granting the State the right to inundate the encumbered land with floodwaters, the easements preclude landowners from building or maintaining encroachments (structures, berms or vegetation) that would affect operations and maintenance requirements or obstruct flood flows.*

The Workplan concepts outlined above clearly state the importance of flood protection and public safety. The Workgroup has consistently believed this to be an important aspect to be captured in the Workplan.

5.6 – Cache Creek Settling Basin (CCSB)

The CCSB is subject to its own TMDL and it is separate from what is covered under this Workplan. The Workplan that is the subject of this request only pertains to open water allocations outlined in the TMDL in order to comply with requirements set forth by the RWQCB (See Section 1.4.3 of the Workplan).

5.7 – Staff Analysis

Staff is in agreement with the modeling effort proposed in the Workplan to better understand the mercury issues in the Delta and Yolo Bypass. Since there are no specifics known and feasible alternatives at this point to reduce methylmercury in open water that will not affect flood control the most practical direction from staff's perspective is to produce a model and collect data. This method will not impact flood control and staff is in support of an alternative that will meet our requirements of the TMDL and will not adversely impact the system.

6.0 – AGENCY COLLABORATION

Upper management of the agencies listed in Section 2.0 is concurrently reviewing the Draft Final Workplan to obtain their respective approvals to send letters in support of the concepts of the Workplan. Due to agency staff collaboration throughout the process and development of this Workplan it is anticipated that the five cooperating agencies will meet the April 20, 2013 deadline for submitting the Workplan to the RWQCB. These efforts mark an important cooperative milestone met by many agencies with varying interests, and staff is prepared to continue its involvement throughout the process.

7.0 – STAFF RECOMMENDATION

Staff recommends that the Board delegate the Executive Officer authority to sign a letter to the RWQCB (Attachment A) expressing Board's support of the Workplan in substantially the form provided.

8.0 – LIST OF ATTACHMENTS

A. Draft Board Methylmercury Control Study Workplan Support Letter

B. Final Draft Methylmercury Control Study Workplan

C. Board Comment Letters on the Regional Water Quality Control Board
   a. Board Comment Letter on BPA to the RWQCB (dated April 9, 2008)
   b. Board Comment Letter on BPA to the RWQCB (dated August 13, 2009)
   c. Joint Comment Letter on BPA to the RWQCB (dated April 7, 2010)

D. Letter from the RWQCB stating the requirements of the BPA (dated November 30, 2011)

E. Board Letter to the RWQCB indicating its intent to work collaboratively (dated April 10, 2012)

F. Workgroup Email Submittal and Concept Proposal (dated August 17, 2012)

Prepared by:	Nancy Moricz, PE
Document Review:	David Williams, PE, Projects Section Chief
	Eric R. Butler, PE – Projects and Environmental Branch Chief
	Len Marino, PE – Chief Engineer

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY **EDMUND G. BROWN JR.,** GOVERNOR

CENTRAL VALLEY FLOOD PROTECTION BOARD
3310 El Camino Ave., Rm. 151
SACRAMENTO, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-2380 FAX: (916) 574-0682

March 22, 2012

Dr. Janis Cooke,
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670

Dear Dr. Cooke,

This letter confirms the Central Valley Flood Protection Board's support of the Methylmercury Control Study Workplan dated April 19, 2013 submitted on behalf of members of the Open Water Workgroup.

If you have any other questions or need additional information, please contact Ms. Nancy Moricz at (916) 574-2381 or by email at nmoricz@water.ca.gov.

Sincerely,

Jay S. Punia, Executive Officer
Central Valley Flood Protection Board

cc: Mr. Len Marino, Chief Engineer
Mr. Eric R. Butler, Chief Projects and Environmental Branch
Mr. David R. Williams, Chief Projects Section
Ms. Nancy C. Moricz, Water Resources Engineer
Central Valley Flood Protection Board
3310 El Camino Avenue, Room 151
Sacramento, CA 95821

Mr. Frederick Gius
Department of Water Resources
3310 El Camino Avenue, Room 110
Sacramento, CA 95821

Ms. Carol DiGiorgio, Program Manager
Department of Water Resources
Mercury Monitoring and Evaluating Section
PO Box 942836
Sacramento, CA 94236-0001

DRAFT

METHYLMERCURY CONTROL STUDY WORKPLAN

APRIL 19, 2013

Prepared by:

The Open Water Workgroup

Department of Water Resources

Central Valley Flood Protection Board

California State Lands Commission

U.S. Army Corps of Engineers

U.S. Bureau of Reclamation

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LIST OF ACRONYMS

ADCP	Acoustic Doppler Current Profiler
BDCP	Bay Delta Conservation Plan
CALFED	CALFED Bay-Delta Program
CALSIM	CALSIM Water Resources Simulation Model
CBD	Colusa Basin Drain
CCR	California Code of Regulations
CCSB	Cache Creek Settling Basin
CEQA	California Environmental Quality Act
chl a	Chlorophyll-a
CSLC	California State Lands Commission
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
Delta	Sacramento San Joaquin Delta
DFW	Department of Fish and Wildlife
D-MCM	Dynamic Mercury Cycling Model
DMCP	Delta Mercury Control Program
DOC	Dissolved Organic Carbon
DON	Dissolved Organic Nitrogen
DSM2	Delta Simulation Model 2
DWR	Department of Water Resources
EC	Electrical Conductivity
EPRI	Electric Power Research Institute
FLIMS	Field and Laboratory Information Management System (DWR)
HCl	Hydrochloric Acid
Hg	Mercury
Hg(II)	Inorganic mercury (total Hg minus MeHg minus elemental Hg)
ICP	Inductively Coupled Plasma Spectrometer
ICPMS	Inductively Coupled Plasma Mass Spectrophotometer
MeHg	Methylmercury
MLML	Moss Landing Marine Laboratories
NH4	Ammonium
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NO2	Nitrite
NO3	Nitrate
QAPP	Quality Assurance Project Plan
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee (CVRWQCB)

THg	Total Mercury (Hg(II), MeHg, elemental Hg)
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
U.C.	University of California
USACE	U.S. Army Corps of Engineers
USBR	US Bureau of Reclamation
US EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSS	Volatile Suspended Sediment
UVA254	Ultraviolet absorbance at 254 nanometers
WDL	Water Data Library (DWR)
Workgroup	Open Water Workgroup

UNITS OF MEASURE

cfs	cubic feet per second
g/day	grams per day
L	liter
mm	millimeter
ng/L	nanograms per liter
µm	micron
µS/cm	microSiemens per centimeter

EXECUTIVE SUMMARY

The Sacramento/San Joaquin River Delta Total Maximum Daily Load (TMDL) establishes a Delta Mercury Control Program (DMCP) as a result of Amendment No. R5-2010-0043 to the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan). The DMCP divides the Sacramento San Joaquin Delta (Delta) and Yolo Bypass into 7 subareas, each of which is then assigned an "open water" methylmercury (MeHg) load allocation in the Basin Plan. Open water allocations encompass three activities: 1) water conveyance operations that may impact Delta in-channel MeHg (e.g., operations of the State Water Project (SWP) and Federal Central Valley Project (CVP); 2) production of MeHg in the Yolo Bypass floodplain inundated by managed floodplain flows; and 3) regulatory or management oversight of activities proposed within open water areas. This open water workplan outlines the approaches the open water workgroup (Workgroup) will use to meet the Phase 1 Control Study requirements associated with the DMCP. All supporting Figures are located in Section 8. The Workgroup consists of the California Department of Water Resources (DWR), California State Lands Commission (CSLC), Central Valley Flood Protection Board (CVFPB), United States Army Corps of Engineers (USACE); and United States Bureau of Reclamation (USBR).

Unlike point sources or traditional non-point sources, SWP and CVP operation and flood management operations upstream of the Delta (e.g., Lake Oroville) are dictated by factors (legal, regulatory and natural) that are beyond the control of the Workgroup. The existence of regulatory and policy circumstances, that make actual operational changes undesirable and infeasible to control study manipulation, have motivated the Workgroup to propose the use of a modeling approach to gain understanding of the complex processes that could occur with operational and flood management changes.

The objective of this workplan is to provide two working models, one for the open waters of the Delta and one for the Yolo Bypass, to examine the impact on MeHg supply of proposed operational changes in water management and flood conveyance in the Delta and Yolo Bypass. Subject to funding, schedule or technical constraints, if the two models can be developed successfully, an effort may be made to integrate the two models into one large-scale model. As proposed, a combination of field data and mechanistic modeling will be used. The scope of modeling will include hydrodynamics, particle transport and mercury fate and transport.

The workplan outlines two phases. The primary objectives of Phase 1 are to (a) incorporate mercury (Hg) cycling and sediment processes into an existing hydrodynamic model of the Delta and create a simplified, working model for the Yolo Bypass, and (b) collect data in the Yolo Bypass to elucidate fundamental MeHg processes under flooding events. These tools and data will be used to examine our understanding of factors governing MeHg supply, and potentially evaluate different operational scenarios. The primary objective of Phase 2, subject to funding, is to build upon data collection needs from Phase 1 and further enhance modeling tools and datasets, if needed, to refine estimates of existing and potential future MeHg supply to the Delta and Yolo Bypass.

For the Delta, process-oriented and mass balance biogeochemical Hg cycling routines will be integrated into the DWR Delta Simulation Model 2 (DSM2) hydrodynamic model (Appendix A), to develop testable hypotheses of how Hg dynamics are expected to operate in the Delta. For the Yolo Bypass, a similar, well calibrated, publically available, hydrodynamic model does not exist, therefore, simplified flow patterns will be used as inputs to the Dynamic Mercury Cycling Model (D-MCM), configured with a limited number of cells.

Conceptual models proposed in this workplan will serve as the starting point for hypothesis testing. The models will be used to further develop and test hypotheses regarding Hg cycling and factors governing MeHg supply in the Delta and Yolo Bypass. Sensitivity analysis and scenario testing provides a basic understanding of the important processes governing MeHg production and how open water and flood conveyance load allocations could be impacted under different proposed operational scenarios. The choice of scenarios to examine will be influenced by future policy decisions and will be determined by the Workgroup. Possible scenarios to be tested are provided in this workplan.

It is anticipated that data gaps currently preclude the ability to adequately understand factors governing MeHg in the Yolo Bypass under flood conditions. Field monitoring will therefore also be used to provide needed information for the Yolo Bypass model. These studies will examine whether MeHg supply to the water column in the Yolo Bypass is dominated by sediment production or remobilization under different flooding events. Depending on field sampling results, laboratory experiments will be conducted that examine flux rates based on soils and land use type, flooding cycles, and particulate MeHg resuspension. The field, and possibly laboratory studies, focuses on testable hypotheses to determine what are the important influences behind MeHg production under flood conditions in the Yolo Bypass.

From an available funding perspective, the proposed field and laboratory experiments represent a best case scenario. Currently, the DWR is funding all TMDL required open water studies as well as DWR, TMDL related studies associated with non-point source wetland control strategies, exposure reduction, and possible dredging work. Therefore, the proposed field and laboratory experiments and scheduling responsibilities may be subject to change to accommodate all DWR TMDL funding and scheduling responsibilities within the TMDL Phase 1 study period. The Workgroup will continue to pursue other avenues of funding to supplement the DWR’s funding.

Additionally, the DWR is currently studying sediment transport and Hg loads within the Cache Creek Settling Basin (CCSB) and lower Cache Creek watershed under a separate TMDL. Work is being conducted for DWR by the U.S. Geological Survey (USGS) and the University of California (U.C.) Davis. The Workgroup recognizes that any Hg control efforts implemented for the CCSB will directly impact Hg loads into the Yolo Bypass. Therefore, an objective of the Workgroup is to work with the USGS and U.C. Davis to examine the implications of CCSB studies and Hg in the Yolo Bypass.

Finally, as new permits are issued or come up for renewal, the CVFPB, the CSLC, and the USACE will examine these permits/leases to determine what modifications are necessary, to address the mobilization and transport of sediment-bound mercury.

1.0 PROBLEM STATEMENT

1.1 Introduction

The Sacramento/San Joaquin River Delta Total Maximum Daily Load (TMDL) establishes a Delta Mercury Control Program (DMCP) as a result of Basin Plan Amendment No. R5-2010-0043. The DMCP divides the Sacramento San Joaquin Delta (Delta) and Yolo Bypass into 7 subareas, each of which is then assigned an "open water" methylmercury (MeHg) load allocation in the Basin Plan. Open water allocations encompass three activities: 1) water conveyance operations that may impact Delta in-channel production; 2) flood management operations that may impact MeHg production in the Yolo Bypass; and 3) regulatory or management oversight of activities proposed within open water areas.

Table 1 shows the current load, allocation, and percent reduction required by the Central Valley Regional Water Quality Control Board (CVRWQCB) for open water in each subarea. Open water allocations apply to the MeHg load that fluxes to the water column from sediments in open-water habitats within channels and floodplains in the Delta and Yolo Bypass. The load allocations apply to the net MeHg loads, where the net loads equal the outflow MeHg load minus the MeHg loads in source water (e.g., irrigation water and precipitation).

Table 1. MeHg Load and Waste Load Allocations for Each Delta Subarea by Source Category

	Central Delta			Marsh Creek			Mokelumne River			Sacramento River		
	Current Load (g/yr)	Allocation (g/yr)	% Reduction	Current Load (g/yr)	Allocation (g/yr)	% Reduction	Current Load (g/yr)	Allocation (g/yr)	% Reduction	Current Load (g/yr)	Allocation (g/yr)	% Reduction
Open Water	370	370	0.0%	0.18	0.032	82.2%	4	1.4	65.0%	140	78	44.3%

	San Joaquin River			West Delta			Yolo Bypass		
	Current Load (g/yr)	Allocation (g/yr)	% Reduction	Current Load (g/yr)	Allocation (g/yr)	% Reduction	Current Load (g/yr)	Allocation (g/yr)	% Reduction
Open Water	48	17	64.6%	190	190	0.0%	100	22	78.0%

Derived from Table A, Attachment 1, Sacramento San Joaquin River Delta Mercury TMDL Resolution NO. R5-2010-0043. Percent reduction is calculated from the difference between the current load and the allocation.

Unlike point sources or traditional non-point sources, operation of the State Water Project (SWP), the Federal Central Valley Project (CVP), and flood management operations upstream of the Delta (e.g., Lake Oroville) are dictated by factors (legal, regulatory and natural) that are beyond the control of the entities primarily responsible for carrying out operations. Hence, evaluation of different management practices do not easily lend themselves to control studies that can quantify changes in MeHg production as a function of operational modifications. The reason is simple: Even if operational changes could be identified that might alter MeHg cycling in a way that would contribute to the desired load reductions, existing operational constraints together with other considerations (water supply, power generation and natural resource considerations) limit the ability of operational entities to implement such measures (even for short term testing). The existence of circumstances which make actual operational changes undesirable and infeasible, have, motivated the Open Water Workgroup (Workgroup) to propose a modeling approach. The use of a modeling approach will help us gain an understanding of the complex processes associated with operational and flood management changes (Concept Proposal, September 2012).

The model development described in this workplan will enhance the understanding of mercury (Hg) processes within the Delta and the Yolo Bypass. It will also enable the Workgroup to evaluate the potential effects of operational changes on Hg cycling and MeHg supply. What can ultimately be accomplished will depend in large part on whether or not adequate funding can be obtained.

In order to understand the constraints to changes in open water operations or flood waters in the Yolo Bypass, it is important to understand the context in which these systems operate. Laws, regulations, permits, water rights, and agreements all play a part in governing the management of water resources in the Delta. Mercury reduction in open waters within the Delta is one concern among many that must be measured against other competing interests. An understanding of the existing operational environment is key to understanding what means are available to address concerns about MeHg in the Delta. The following subsections describe the existing operational environment and the operational and regulatory context under which the systems operate.

1.2 Operational Environment of the Water Projects

The Department of Water Resources (DWR) operates the SWP, the largest state-built multipurpose water project in the United States. The SWP provides water for approximately 25 million Californians and serves the additional purposes of power generation, flood control, recreation, and the enhancement of fish and wildlife. It consists of approximately 700 miles of open canals and pipelines, 28 dams, 20 pumping plants, five hydroelectric power plants, and three pumping/generating plants.

The United States Bureau of Reclamation (USBR) operates the Federal Central Valley Project (CVP), one of the Nation`s major water conservation developments. The CVP extends from the Cascade Range in the north to the plains along the Kern River in the south. The CVP improves Sacramento River navigation, supplies domestic and industrial water, generates electric power, conserves fish and wildlife, creates opportunities for recreation, and enhances water quality. The CVP serves farms, homes, and industry in California`s Central Valley as well as major urban centers in the San Francisco Bay Area; it is also the primary source of water for much of California`s wetlands.

1.3 Management Activities and Regulations—Open Water

1.3.1 Water Rights

The SWP and CVP are subject to several water right permits issued by the State Water Resources Control Board (SWRCB). Water Right Decision 1641 (D-1641), issued by the SWRCB on December 29, 1999, as amended March 15, 2000, contains terms and conditions that are intended to protect municipal and industrial, agricultural, and fish and wildlife beneficial uses of the Delta. In addition to setting water quality criteria that translate into operational standards within the Delta and the Delta watershed, the SWRCB also sets in-stream flow standards (Figure 1).

The SWP and the CVP are operated in coordination to meet the terms in D-1641 relevant to each project. Operating these projects to meet specific numerical criteria at specific locations in the Delta is a daunting task made more difficult by California's naturally highly variable annual precipitation and the dynamic nature of the Delta estuary. Reservoir releases take one to five days to reach the Delta. Meeting water quality objectives for the Delta requires continual monitoring of Delta conditions and forecasting of future conditions and careful coordination of reservoir releases and pumping operations. Levee breaks, unexpected high discharges of salts, limited circulation in some parts of the Delta, and other factors affecting water quality are beyond the control of the operation of the SWP/CVP. The water quality objectives for the south Delta are particularly difficult to meet through operating the SWP/CVP because the water quality at these locations is predominantly driven by the upstream water quality of the San Joaquin River, agricultural discharge return flows and limited circulation in local channels; none of which is within the control of the SWP/CVP.

1.3.2 Endangered Species

The DWR must obtain authorization for any taking of threatened or endangered species that would result from any act authorized by D-1641. In 2004, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) issued updated biological opinions for operations of the CVP and SWP which cover impacts and incidental take of the listed salmonid species and delta smelt (Figure 2). In addition, DWR continues to obtain incidental take coverage for endangered species pursuant to the California Department of Fish and Wildlife (DFW) Code Section 2081.1, based on agreements and memorandums entered into with the DFW prior to April 10, 1997. Together, these authorizations and agreements impose strict constraints on how and when the SWP can move water.

1.3.3 Water Quality and Flow Criteria

Additional operational changes are on the horizon for the CVP and SWP. The SWRCB has initiated a phased process to review and amend—or to adopt new—water quality and flow objectives for the Delta by 2014. Phase 1 of that review is focused on southern Delta water quality and San Joaquin River flows. Phase 2 is focused on other changes that may be needed to the remainder of the Bay-Delta Water Quality Plan to protect fish and wildlife beneficial uses. The SWRCB is also reviewing the Bay-Delta Conservation Plan (BDCP) and associated implementation will significantly change the operational requirements of each project.

1.4 Management Activities and Regulations – Flood Management

1.4.1 The Central Valley Flood Protection Plan

Following Hurricane Katrina, an analysis of flood prone areas in the United States determined that Sacramento is the most flood-prone city in the nation (Prudhomme, 2011). The Central Valley Flood Protection Plan (CVFPP) was adopted by the Central Valley Flood Protection Board (CVFPB) in June 2012 (DWR, 2012a). The Flood Plan is designed to provide conceptual guidance that will reduce the risk of flooding in the Central Valley. The guidance is designed to incorporate urban area, small community and rural agricultural flood risks. Flood mobilization of mercury laden sediments is a significant factor when describing mercury transport and distribution within a watershed. However, while these effects must be understood, in order to model mercury cycling, changes to the way that flood events are managed are unlikely to provide a feasible means of addressing elevated mercury levels because flood control is a public safety action that takes precedence over water quality.

1.4.2 Yolo Bypass

The Sacramento River Bypass system was federally authorized in 1917. It includes a system of flood relief structures and weirs that release Sacramento River flows into the bypass system when flows exceed downstream channel capacity at five locations, from the latitude of Chico to Sacramento. At the latitude of Sacramento, the Yolo Bypass carries 80 percent or more of flood flows southward to the Delta (DWR, 2012a).

Runoff from the entire Sacramento Valley watershed reaches the Delta via the lower Sacramento River and the Yolo Bypass. The Sutter and Yolo Bypasses, in combination with their control features—the Moulton, Colusa, Tisdale, Fremont, and Sacramento weirs/bypasses—function as the central backbone of the Sacramento, Feather, and American rivers flood control infrastructure, conveying up to 490,000 cubic feet per second (cfs) during large flood events. The considerable capacity of the Yolo Bypass system also slows the movement of floods, effectively attenuating flood peaks and metering flows in the Delta (DWR, 2012a).

Flood waters channeled into the Yolo Bypass are subject to a wide range of regulatory and operational procedures. The DWR is responsible for operation of Lake Oroville on the Feather River upstream of the Yolo Bypass. One purpose of Lake Oroville, is to regulate flood flows through the careful management of reservoir releases to minimize flood damages downstream. Operation of this flood control structure is regulated by Flood Control Criteria of the U.S. Army Corps of Engineers (USACE). The USACE Release Guide dictates floodwater releases from the Oroville Dam based on the actual or forecasted inflows and the flood control space available in the reservoir. These regulatory criteria in-turn influence the flood flows that can enter the Yolo Bypass. Releases are highly choreographed between a number of different Federal and State agencies and other local stakeholders.

Changes to operation of the Yolo Bypass must be approved by the CVFPB and other appropriate authorities, if applicable. Within the Yolo Bypass, land use is restricted by easements held by the CVFPB pursuant to California Code of Regulations (CCR), Title 23 and 33 United States Code (USC) Section 408. In addition to granting the State the right to inundate the encumbered land with floodwaters, the easements preclude landowners from building or maintaining encroachments (structures, berms or vegetation) that would affect operations and maintenance requirements or obstruct flood flows.

1.4.3 Cache Creek Settling Basin

Through an agreement with the USACE, DWR is responsible for the operation and maintenance of the Cache Creek Settling Basin (CCSB) in Yolo County. The basin acts as a sediment trap by capturing the flashy storm flows from Cache Creek and allowing the sediment to settle before exiting into the Yolo Bypass. The CCSB is subject to its own TMDL (CVRWQCB, 2005) separate from the TMDL covered under this workplan.

1.5 Responsible Trustee Agencies

Many projects, both within and upstream of the identified Delta TMDL area can result in mercury deposition or MeHg formation in open water areas of the Delta, which are under the jurisdiction of State and/or Federal agencies.

1.5.1 CSLC, CVFPB, and Other State Agencies

State agencies, such as the CVFPB and the California State Lands Commission (CSLC), may act as trustee agencies under the California Environmental Quality Act (CEQA) in reviewing projects as mentioned above. The CSLC currently requires a lease for those activities (e.g., dredging, riprap installation, spur dike removal) within its jurisdiction that contribute to the disturbance of streambed sediments. To more effectively modify future leases to address the mobilization and transport of sediment-bound Hg, the CSLC will, as part of this workplan, conduct an examination of current effective methodologies to strengthen existing best management practices or develop new control measures aimed at reducing the concentration of Hg and/or MeHg released into the Delta due to sediment disturbance.

1.5.2 USACE, USBR, and Other Federal Agencies

Federal agencies, such as the USACE and the USBR, may act as trustee agencies under the National Environmental Policy Act (NEPA). In addition, the USACE may also require permits for activities within waters of the U.S. that may also contribute to the release of sediment-bound mercury.

2.0 OBJECTIVES

The primary objectives of this workplan are to:

1. Provide working models for Hg and MeHg supply, transport and fate in the open waters of the Delta and Yolo Bypass;
2. Apply the models to identify processes governing MeHg supply to the Delta and Yolo Bypass;
3. Apply the models to examine the potential impacts on MeHg supply of proposed operational changes in water management and flood conveyance in the Delta and Yolo Bypass, and compare to TMDL allocations; and
4. Use existing data, to the extent possible, supplemented, as needed to meet objectives 2 and 3 above. This includes collecting sample data in the Yolo Bypass and the laboratory to elucidate fundamental MeHg processes under flooding events.

The study will be carried out in two Phases. Phase 1 will include the initial development and application of models for the Delta and Yolo Bypass, and will identify modeling, knowledge or data gaps. The scope of modeling will include hydrodynamics, particle transport and Hg fate and transport, which will be supported with field or laboratory data. Phase 2, subject to funding, will involve further enhancements of modeling tools and datasets as needed to refine estimates of existing and potential future MeHg supply to the Delta and Yolo Bypass, and adequately provide input to the MeHg TMDL process.

Conceptual models, discussed in Section 3.0, for MeHg sources and sinks in the Delta and Yolo Bypass reflect hypotheses of our current understanding of the two systems. Simulation modeling described in Section 5.0 will test and refine hypotheses regarding (1) factors controlling the existing supply of MeHg to the Delta and Yolo Bypass, and (2) potential effects of operational changes to the system in terms of MeHg supply.

The models discussed in this workplan also may help evaluate the potential impacts in the Delta and Yolo Bypass of actions proposed by other groups with MeHg TMDL requirements (e.g., upstream, wetlands, agricultural inputs, CCSB). While this type of evaluation is not the direct mandate of the Workgroup, it would be very useful to have such a tool in the broader context of integrating effects of various groups taking actions to meet TMDL needs. The modeling carried out in this study may also provide the CVRWQCB staff with a mechanism to evaluate future regulatory proposals and prioritize and focus future actions.

2.1 Hypotheses – Factors Governing MeHg Concentrations and Processes

Phase 1 modeling will focus on testing hypotheses regarding governing factors and assumptions for MeHg processes for the Delta and Yolo Bypass (as outlined in Figure 3 and Figure 4, respectively). These hypotheses include:

2.1.1 Delta Hypotheses

1. Tributary loads are the primary source of MeHg to the Delta on an annual basis and during the winter/spring periods;
2. Wetlands, the atmosphere, agricultural returns and open water sediment exchange are important sources of MeHg to the Delta during low flow conditions in summer and fall;
3. Wetlands, agricultural returns and open water sediment exchange are important sources of MeHg to certain hydraulically isolated Delta areas, and;
4. The primary loss mechanism for MeHg in the Delta is outflow (approximately half).

2.1.2 Yolo Bypass Hypotheses

Foe and others (2008) defined two different flooding scenarios in the Yolo Bypass; a) mini-flood events, defined as when flows in Cache and/or Putah Creeks are greater than the carrying capacity of their channels resulting in local flooding, (no spillage over Fremont Weir), and b) flood events, defined as flows in the Sacramento River of approximately 56,000 cfs resulting in overtopping of the Fremont Weir and wide-scale flooding of the Yolo Bypass. Based on this information emphasis will be placed on the effects of seasonal differences in hydrology (wet and dry cycles, small versus large flood events), and the effects of terrain type on MeHg production in Yolo Bypass sediments. This is important because in-situ MeHg production is a significant MeHg source in the conceptual model for the Yolo Bypass (Figure 4).

In flood waters associated with the Yolo Bypass, the model will be used to understand factors governing MeHg processes. The primary hypothesis that will be tested is:

> During flood events, in-situ production, sediment resuspension and tributary inflows are the primary sources of MeHg to the Yolo Bypass. The relative importance of these sources varies temporally and spatially in relation to the size and timing of a flood event and sediment type.

2.2 Control Objectives and Hypotheses

The primary objectives related to management practice controls are to use modeling to evaluate and investigate the influence of potential changes to water operations practices or conveyance schemes on MeHg in the Delta and Yolo Bypass.

TMDL MeHg load allocations are divided into seven subareas: the Central Delta, the Western Delta, Marsh Creek, the Sacramento River, Mokelumne/Cosumnes Rivers, the Yolo Bypass, and the San Joaquin River subareas (Table 1). Open water allocations are associated with the sediment flux from each of these subareas. Allocation reductions range from no reductions in the Central and West Delta subareas to load reductions ranging between 44 to 82% in the remaining subareas.

Model simulations will be carried out to represent proposed alternative water operations practices and water conveyance schemes. Simulations will also include sensitivity analyses to examine which model inputs have the greatest influence on MeHg supply. A preliminary list of control-related hypotheses that could be tested includes:

2.2.1 Delta Control-related Hypotheses

1. Reduced annual flow to the Delta will not significantly affect MeHg production in open water sediments;
2. Seasonal or short term shifts in flow management will not significantly affect MeHg production in open water sediments;
3. Installation of permanent barriers to control the ratio of San Joaquin to Sacramento River water will not significantly affect MeHg production in open water sediments;
4. An alternate conveyance will not significantly affect MeHg production in open water sediments;
5. Operational changes required to maintain current or future Delta salinity standards will not impact MeHg production in open water sediments, and;
6. Revision of the San Joaquin River flow objectives or the development and implementation of in-stream requirements will not impact MeHg production in open water sediments.

2.2.2 Yolo Bypass Control-related Hypotheses

1. Water management to restrict flood flows over sediments with higher total Hg (THg) concentrations would reduce MeHg production in the Yolo Bypass;
2. Yolo Bypass soils in the winter that remain moist show reduced MeHg production;
3. Widening the Yolo Bypass to increase floodwater inundation would increase MeHg production;
4. Changes to areas inundated by flood waters due to notching of the Fremont Weir would reduce MeHg production, and;
5. Reduced MeHg supply from the CCSB would meaningfully reduce overall MeHg supply to the Yolo Bypass. (While this hypothesis is not within the control of the Workgroup, it will be tested, as could other hypotheses related to the effects of actions by other groups to meet TMDL requirements).

3.0 MECHANISMS UNDERLYING THE STUDY

Aquatic ecosystems such as the Delta are highly complex and variable on temporal and spatial scales. Mercury also has a complex biogeochemistry in aquatic systems. Hence, predicting the effects of remedial actions and changing ecosystem conditions on the concentration, bioaccumulation and cycling of Hg and MeHg in settings such as the Delta is a difficult task. To address this need, the next phase of research requires a quantitative, multivariate modeling approach so that the Workgroup can understand why a given management strategy may have different outcomes at different sites. Because Hg transformations and transport through the Delta are influenced by a many variables, and because open-water habitats within channels and floodplains in the Delta and Yolo Bypass are not independent from their neighboring habitats, a modeling approach will be necessary to bracket the possible outcomes of different management practices.

Examination of a complex problem such as MeHg supply to the Delta and Yolo Bypass will be facilitated through the use of a conceptual model that describes the current understanding of Hg cycling in the system. The process of developing a conceptual model requires the study team to develop hypotheses regarding the key processes and features of the Delta and Yolo Bypass that affect MeHg concentrations and fluxes. The conceptual model can be used to help identify where existing data are adequate and what type of new information is needed. A conceptual model of Hg cycling and bioaccumulation has previously been assembled by Alpers and others (2008) for Hg in the Delta. Windham-Myers and Ackerman (2012) subsequently reviewed additional information available on Hg in the Delta from 2008-2012. This workplan provides an outline of conceptual models that specifically examine processes that influence MeHg concentrations and transport in the Delta and Yolo Bypass.

3.1 Delta Open Water Conceptual Model

Estimates of sources and sinks of MeHg into the Delta and Yolo Bypass compiled by C. Foe of the State Regional Water Quality Control Board (C. Foe pers. comm.) are illustrated in Figure 3 (updated from CVRWQCB, 2010). The annual mass balance for MeHg suggests that there is a MeHg loss term (of unknown origin) within the Delta on the order of 1.4 g/day. The process(es) representing the unknown loss term is not currently known. The unknown sink could be due to incorporation into biota (which has not been estimated), it could be due to a process not recognized to be important, or it could simply be due to errors in the estimation of the flows associated with the various sources and sinks represented in the figure. These sources and sinks manifest to create a spatial trend where the lowest MeHg concentrations in open water occur in the central and western Delta (Stephenson, pers. comm.).

A conceptual model and hypotheses can be derived based on this information that MeHg enters the Delta from a variety of sources, with tributary inputs (Cache Creek, Sacramento River, San Joaquin River, etc.) being dominant (91%). Less important, but significant inputs come from waste water treatment plants (3%), sediment-water exchange (3%), agricultural returns (2%) and wetlands (1%). Inputs from urban run-off and direct atmospheric deposition of MeHg are believed to be small sources (< 1% of the total input). Tributary input tends to dominate during high flow conditions, primarily in winter and early spring. Wetlands, agricultural returns and open water benthic exchange fluxes become important only during low flow conditions during summer and fall. Non-tributary sources can become dominant in isolated waterways where water residence times can reach 10’s to 100’s of days during low tributary flow periods. Major MeHg losses occur through riverine flow through the San Francisco Bay estuary (54%), incorporation into suspended material, sedimentation and burial (27%), loss by photodemethylation (14%), and export of water to southern California (8%) (Figure 3). The loss due to incorporation of MeHg into biota is most likely wholly or partially accounted for by the sedimentation and burial term. The unknown loss term accounts for 8% of the total sinks for MeHg. Loss by photodemethylation occurs predominantly in the summer months when solar light flux and photoperiod are maximal.

3.2 Yolo Bypass Conceptual Model

The Yolo Bypass is a 59,000-acre flood conveyance system designed to divert storm water from the Sacramento River around the City of Sacramento. Extensive historical Hg mining occurred in both the Cache and Putah Creek watersheds. These tributaries are two of the major sources of Hg and MeHg to the Yolo Bypass. Hydrology in the summer is characterized by low tributary inflows, coupled with a high demand for irrigation water. Irrigation water drawn from Cache and Putah Creeks is supplemented by water from the Delta. This demand creates a reverse flow resulting in Sacramento River water traveling north into the Yolo Bypass area.

In the wetter seasons, there are small flood events that occur approximately 85% of the time from Cache and Putah Creeks and the Knights Landing Ridge Cut. Approximately 70% of the time, when these tributaries overflow, the Fremont Weir also overtops, resulting in more extensive geographic flooding with flooding and drainage periods potentially lasting several months (M. Kirkland, pers. comm.). Average monthly MeHg concentrations increase statistically when the Yolo Bypass is used for flood conveyance (0.25 to 0.70 ng/L, $P<0.01$) and MeHg production increases as a function of flow (Foe and others, 2008). The Yolo Bypass can become the single largest source of MeHg to the Delta during major flooding events, accounting for over 40% of the tributary load (Foe and others, 2008).

A conceptual model for the Yolo Bypass for small flood events (< 5000 cfs) is given by the mass balance model in Figure 4. During small flood events, Cache Creek and the Knights Landing Ridge Cut are the major tributary inputs of MeHg; Putah Creek becomes a much less significant source. During small flooding events, MeHg production within the Yolo Bypass is also very significant. Under these flow regimes, in-bypass production, on average, was 37% of tributary inputs. At higher flow rates (between 5,000 and 110,000 cfs), MeHg production within the Yolo Bypass was > 50% of the tributary inputs. In some events between 5,000 and 20,000 cfs, in-bypass production was >70% of tributary inputs (Foe and others, 2008). Most of the MeHg introduced from the tributaries is exported to the

Sacramento River. However, some MeHg is lost in the Lower Yolo Bypass near the Liberty Island Complex which is a sink for MeHg (Foe and others 2008). We hypothesize that the loss may be a result of particle settling. During flooding events the residence time of water in the Yolo Bypass is thought to be a few days. Therefore, processes like photodemethylation of MeHg and atmospheric deposition of Hg may become less important than in the Delta, where residence times during flood events are on time scales of weeks. It is unknown what land use within the Yolo Bypass is responsible for MeHg production during flooding events (i.e. agriculture vs. managed wetlands). One of the largest data gaps is understanding what mechanism(s) are responsible for production within the Yolo Bypass during flooding events. It is unknown whether MeHg production is a result of a sediment-water flux (a dissolved input) or sediment erosion (a particle flux). Identifying which of these processes dominates will help to develop management practices to reduce MeHg sources within Yolo Bypass and improve the accuracy of the model under different flooding scenarios.

3.3 Need for Mechanistic Modeling

While conceptual models can qualitatively describe how Hg and MeHg behave in a system, more quantitative approaches are needed to test hypotheses regarding MeHg behavior or predict how future management changes to operational conditions will influence MeHg concentrations on temporal and spatial scales. Process-based simulation modeling is needed so that the Workgroup can understand why a given management strategy may have different outcomes in different sites and seasons. Because Hg transformations and transport through the Delta are influenced by many variables and because open-water habitats within channels and floodplains in the Delta and Yolo Bypass are linked to neighboring habitats, a modeling approach will be necessary to bracket the possible outcomes of different management practices. Without quantification, the net expected effects of a given management practice will be difficult to estimate.

Modeling tools will be used in this workplan to simulate existing conditions and better understand Hg cycling, and identify areas where additional data collection or research are needed to refine and constrain predictions.

4.0 PROPOSED CONTROL MEASURES

The approach planned in this workplan is a multi-agency effort that will create a tool that can be used, not only by the Workgroup, but potentially by the broader Delta regulated MeHg community. With modeling, the CVRWQCB and other MeHg stakeholders can ask predictive questions about how changes to the Delta and Yolo Bypass system could affect MeHg production.

Unlike point sources or traditional non-point sources, operation of the SWP, CVP, and flood management operations do not easily lend themselves to control studies and hypothesis testing that can quantify changes in MeHg production as a function of operational modifications. In addition to difficulties that originate from the underlying nature of the projects, development of control studies are also made difficult because, in some cases, the basic processes that drive production and degradation of MeHg in the area have not been previously studied (e.g., the Yolo Bypass). Under these circumstances, the important drivers of MeHg production and the degradation in the system are not understood. This lack of knowledge makes it difficult to generate meaningful and testable hypotheses on how MeHg production would change if modifications were made to flood operations or State and Federal Water Project operations.

Therefore, the Workgroup proposes to use a modeling approach to examine the impacts of changes in project and flood operations on MeHg production and degradation. This approach may provide a tool to examine whether proposed operational modifications could affect MeHg production and export. A scientific model could be used to gain insight into MeHg sources and the conditions that contribute to MeHg behavior in TMDL open waters. Additionally, data collected and used to calibrate and verify the model may provide meaningful insight into the processes in the Delta and Yolo Bypass that contribute to MeHg production and cycling.

5.0 MODELING AND DATA COLLECTION PLAN

Modeling and data collection will be carried out in a coordinated manner as described in this Section to assemble an understanding of factors governing MeHg supply to the Delta and Yolo Bypass.

5.1 Conceptual Model Development

The conceptual model by Alpers and others (2008), review by Windham-Myers and Ackerman (2012) and conceptual models presented in Section 3.0 are sufficient to use as a starting point for the development of an Hg cycling and bioaccumulation model for the Delta and Yolo Bypass, with an emphasis on MeHg supply. The conceptual models of MeHg supply to the Delta and Yolo Bypass are likely to be refined during the course of the study, as new information emerges.

5.2 Development of Mechanistic Models

Different mechanistic models will likely be used for the Delta and Yolo Bypass in Phase 1. In the Delta, an existing well-established model of hydrodynamics (DSM2, see Appendix A) will be updated with the addition of Hg cycling. Three Hg forms (inorganic Hg(II), MeHg, and elemental Hg) will be included in water and sediments (Figure 5). Key processes include external Hg loads to the modeled area from the atmosphere and streams, physical transport (advection, diffusion, resuspension, settling), and conversions among these Hg forms (biological methylation and demethylation, photo-reduction of Hg(II),photo-oxidation of elemental Hg, and photo-degradation of MeHg). To carry out Hg modeling with DSM2, it will also need the ability to simulate particle transport and Hg in the sediment bed. The DWR is currently developing a sediment module for DSM2, expected to be available by the fall or winter of 2013.

Because a well calibrated hydrodynamic model does not yet exist for the Yolo Bypass, simplified flow patterns will be used during Phase 1 as inputs to an existing model of Hg cycling and bioaccumulation for the Yolo Bypass (D-MCM, see Appendix B), configured with a limited number of cells. The D-MCM includes inorganic Hg(II), MeHg, and elemental Hg. It can be set up as a single cell or in configurations up to 3D as required (Version 4.0), and can simultaneously simulate open waters and wetlands, which can include multiple species of aquatic vegetation. It considers the effects of key factors affecting Hg cycling and bioaccumulation (e.g., hydrology, water quality, trophic structure). The D-MCM was originally developed for small to moderate sized lakes. A new version of the model (D-MCM Version 4.0) proposed for this study is more broadly applicable to lakes, rivers, estuaries, wetlands and marine systems (e.g. Harris and others, 2012). Fish migration is included and is important if fish move among habitats with different MeHg exposures. D-MCM considers water level fluctuations and wet/dry cycles, however the scientific understanding is incomplete.

The cell configuration for the Yolo Bypass simulations will be based on input from Hg modelers, hydrodynamics modelers and other Hg experts working on the study team. Areas where site conditions or Hg concentrations show strong spatial gradients, or where mixing associated with flow is incomplete need more cells to accommodate changing conditions. This modeling approach is expected to help begin to answer potential Yolo Bypass impacts associated with changes in flood conveyance waters (i.e., notching of the Fremont Weir). Pending the contract approval process, development of a biogeochemical mass balance model for mercury in the Delta, and application of the D-MCM model to the Yolo Bypass will be conducted by Reed Harris of Reed-Harris Environmental, Ltd in consultation with hydrodynamic modelers from the DWR.

Although the TMDL addresses MeHg loading rates, modeling will also simulate MeHg bioaccumulation and fish MeHg concentrations. D-MCM includes the ability to simulate MeHg in food webs, and this feature will be used for the Yolo Bypass. Mercury routines added to DSM2 will not include a food web. It is a more efficient use of resources to pass outputs of predicted MeHg concentrations in water and sediments from DSM2 to an existing food web simulation model for MeHg (developed by Reed-Harris Environmental, or a United States Environmental Protection Agency (US EPA) model called BASS (Barber 2006).

Both the Delta DSM2 and the coarse grid model of the Yolo Bypass using D-MCM will be available to the public to install and use the models. In the case of DSM2, but not D-MCM, it will also be possible to view or change source code.

5.3 Model Application to Existing Conditions

Simulations will first be performed to calibrate the models to reflect existing concentrations and fluxes of inorganic Hg and MeHg in the open waters of the Delta and the Yolo Bypass. The models will be used to examine the most important sources of MeHg, either loaded externally or produced within the Delta/Yolo Bypass, supplied by inputs of inorganic Hg(II) from rivers and streams, the atmosphere, and legacy Hg(II) contamination in sediments. Simulations of existing conditions will also be used to test hypotheses regarding key processes and factors governing the supply of MeHg to the Delta and Yolo Bypass. Sensitivity analyses will be performed separately for the Delta and Yolo Bypass, to examine which model inputs and processes have the greatest influence on model predictions.

For DSM2 simulations of open waters, a sensitivity analysis will be used to examine which model inputs contribute the most to uncertainty in model predictions. This will help identify which inputs need to be better constrained (through data collection or experiments) to reduce uncertainty in model predictions. It is also desirable to quantify the confidence limits surrounding predicted mercury concentrations. This can be done in some studies using probabilistic (Monte-Carlo) techniques, but may not be practical when model simulations are time-consuming, such that hundreds or thousands of model iterations would not be feasible. This may be the case for the application of DSM2 to Delta open waters, in which case an assessment of confidence limits surrounding predictions will be more qualitative than quantitative. The model calibration will be optimized by attempting to minimize the error between observations and predictions. This will be carried out by visually examining the fit between model observations and predictions, and where feasible, numerical tests will be used to examine and minimize the sum of squares of errors for key model outputs such as total Hg and MeHg concentrations in the water column and sediments. Also, a key component of our analysis will be a relative ranking of scenarios. As indicated in the modeling guidelines provided by the CVRWQCB (CVRWQCB, 2004), the accuracy of the model is not necessarily as critical for relative rankings, although the issue still arises "How different is meaningfully different?" For D-MCM simulations in the Yolo Bypass, we expect to do a sensitivity analysis and carry out Monte Carlo simulations to help quantify uncertainty associated with model predictions. An estimate of performance objectives can be calculated after we perform an analysis of the observed data, however until that time, providing an estimate of confidence will be premature.

Wetlands are an important component of the Delta and Yolo Bypass, and can be important sources of MeHg to aquatic systems. In the Yolo Bypass, D-MCM can explicitly simulate wetland areas where needed. In the Delta, most of the wetland areas are hydrologically separated from open waters (M. Stephenson pers. comm.). Therefore, for modeling purposes, it was assumed that changes to water operations and alternate water conveyance schemes would not appreciably alter MeHg production in wetlands or the wetland supply of MeHg to open waters. The only exception is in the Liberty Island area where there is connectivity to a large wetland system. In the event more wetlands are created as a result of the BDCP, the assumption of no connectivity will have to be revisited during Phase 1 studies.

5.4 Scenario Modeling

Following sensitivity analyses, specific operational and flood management scenarios will be simulated to examine the impacts on MeHg supply of proposed water management changes in the Delta and Yolo Bypass. A scenario will also be simulated assuming no management of flow (i.e., no reservoir storage, regulated releases, etc.) allowing an assessment of the impact of current project operations and flood management on MeHg production. Although these scenarios do not represent direct control strategies, this approach will create a platform for the study team and the CVRWQCB to understand the impacts of proposed regulatory changes to the system.

5.5 Phase 2 Modeling Studies

As stated above, Phase 2 work, subject to funding, will involve further enhancements of modeling tools and datasets, if necessary, to refine estimates of existing and potential future MeHg supply to the Delta and Yolo Bypass, and adequately provide input to the MeHg TMDL process. DSM2 will continue to be used during Phase 2 to simulate Hg in the Delta, but may be updated if Phase 1 studies identify necessary enhancements. In the Yolo Bypass, the benefits of using a higher spatial resolution modeling approach during Phase 2 will be assessed. Consideration will be given to a high resolution hydrodynamic model if one is available for the Yolo Bypass at that time. For example, the USBR and DWR are in the process of examining modeling in the Yolo Bypass to comply with the terms of the NMFS/USFWS Biological Opinions to increase fishery habitat in the Yolo Bypass. It is anticipated that in the next two to three years, a hydrodynamic model for the Yolo Bypass would be developed. Mercury routines could be added to such a model, or hydrodynamic outputs could be passed to D-MCM, configured with greater spatial resolution.

5.6 Field and Laboratory Sampling

The following subsections focus on the general sample design that will be used to provide rate data to the D-MCM model. Appendix C provides background information on rationale behind sample collection to examine whether MeHg production in the Yolo Bypass is influenced by sediment-water flux or sediment erosion under different flooding conditions.

The field and laboratory experiments outlined in the following subsections represent a best case scenario. However, the DWR is currently funding all TMDL required open water studies as well as DWR, TMDL studies associated with non-point source wetland control strategies, exposure reduction, and possible dredging work. Therefore, the proposed field and laboratory studies and scheduling may be subject to change to accommodate all DWR TMDL funding and scheduling responsibilities within the TMDL Phase 1 study period. The Workgroup will continue to pursue other avenues of funding to supplement the DWR's funding.

In addition to the field and laboratory studies discussed below, the Workgroup may use, where appropriate, data collected from joint DWR-DFW tidal wetland studies of MeHg production in the lower Yolo Bypass to provide data for the D-MCM model.

5.7 Inlet/Outlet Sampling Plans

5.7.1 Sample Timing and Hydrology—Large Flooding Events vs. Mini-Flooding Events

Successful sampling of MeHg processes under different flooding regimes will be dictated by the water year type. However, it is anticipated that samples would be collected over a 2-year period between October and April. Samples would be collected under: a) mini-flood events, defined by Foe and others, (2008) as when flows in Cache or Putah Creeks are greater than the carrying capacity of their channels resulting in local flooding, (no spillage over Fremont Weir), and b) flood events, defined as flows in the Sacramento River of approximately 56,000 cfs resulting in overtopping of the Fremont Weir and wide-scale flooding of the Yolo Bypass.

Samples collected under mini-flood events will focus on Yolo Bypass outflows similar to those predicted to occur with potential notching of the Fremont Weir (between approximately 6,000 and 12,000 cfs). A regression analysis will be developed between the stage gauge at Lisbon Weir and tributary inflows at Fremont Weir, Knights Landing Ridge Cut, CCSB, and Putah Creek. Once this relationship is established, the stage gauge will be used to trigger sampling events. At a stage height of 9 feet (NAVD88 stage), there is a little overtopping of the Toe Drain, which receives localized flood waters from Putah and Cache Creek. It is expected that sample collection will be triggered when the Lisbon gauge is between 11 and 15 feet. This depth corresponds to when the Toe Drain has overtopped its banks due to input from Putah and/or Cache Creek, but floodwaters have not overtopped Fremont Weir. For large flood events, sampling would be triggered by flow in the Sacramento River of approximately 56,000 to 60,000 cfs, which corresponds to overtopping of the Fremont Weir.

Up to 12 sampling events would be captured during each flood season. To adequately characterize MeHg production, under inundation scenarios similar to those envisioned by notching of the Fremont Weir, sampling would target summed outlet flows between 6,000 to 9,000 cfs, 9,000 to 12,000 cfs, 12,000 to 20,000 cfs, and greater than 20,000 cfs (or when the Fremont Weir is overtopped). The number of sampling events will be determined by whether there is enough precipitation in the Cache, Putah, and Sacramento watersheds to create both mini-flood and large scale flood events. Ideally, at least three samples from each flow regime would be captured (see Table 2). If possible, samples will be collected on the rising limb of the hydrograph. Because of the uncertainty associated with flood events, the Workgroup may take advantage of a longer duration storm (approx. four to six days), to collect samples throughout the storm event. Due to costs, sampling events collected throughout a storm would be counted towards the total number of sample events collected in a single season.

5.7.2 Sample Location

Samples will be collected from five input stations and one output station (Table 2, Figure 6). Composite samples will be collected at the Fremont Weir and the outflow structure of the CCSB. Production will be calculated by subtracting the sum of the input masses from the output mass.

Table 2. Location for Yolo Bypass Sampling at Inlets and Outlets

Station Type	Station Name	Sample type	Number of Samples
Inlet	Fremont Weir	Composite grab sample collected from 3 stations immediately upstream and alongside of the weir	1 composite
	Knights Landing Ridge Cut (KLRC)	1 grab	1
	Cache Creek Settling Basin Outflow-Cache Creek Weir (inlet to Yolo Bypass)	Composite grab sample collected from 2 stations on north and south side of weir	1 composite
	Putah Creek at Mace Blvd.	1 grab	1
	Putah Creek at Yolo Wildlife Area.	1 grab	1
Outlet	½ Lisbon, immediately north of the stair steps and ~ 12 miles south of Lisbon Weir	Grab Samples	Up to 10 samples. Results from the same water masses will be averaged. Water masses sampled could include: 1 Fremont Weir 2 KLRC water mass 3 Putah Creek water mass 4 Cache Creek water mass 5 Unidentified water mass

Samples collected from Knights Landing Ridge Cut, the CCSB, and Putah Creek will be collected from land. Samples collected from Fremont Weir and at ½ Lisbon will be sampled by boat. Transect sampling would occur at Fremont Weir and at ½ Lisbon. This will ensure sample representativeness over a wide water body. However, at ½ Lisbon, transect sampling will serve a dual purpose: a) sample representativeness and b) quantification of water mass contributions to MeHg production. An east/west transect conducted near Lisbon Weir would integrate the relative MeHg/total suspended solids (TSS)/turbidity load contributions of tributary flood flows from water masses within the Yolo Bypass (i.e., Putah Creek, Cache Creek, Knights Landing Ridge Cut, and Fremont Weir). A study conducted by Sommer and others (2007) demonstrated that under flood conditions, the Yolo Bypass inlet tributaries segregate into distinct water masses, displaying unique chemical and physical properties that allow identification of the source water (Figure 7).

Foe and others (2008) observed the unique chemical fingerprints of inlet source waters, and suggested that the water leaving the Yolo Bypass is not well mixed and that an accurate estimate of net export will require information about the concentration and water volume discharged down each channel. To some extent, the input water masses can be identified by their Electrical Conductivity (EC) signatures which are higher in the Knights Landing Ridge Cut, Cache Creek and Putah Creek than water originating from Fremont Weir (Table 3).

Table 3. Summary of Electrical Conductivity Measurements

	Fremont Weir					
Date	**upper**	**mid**	**lower**	**Ridge Cut**	**Putah**	**Cache**
28-Feb						
3-Mar	109	107	148	294	344	237
7-Mar	133	133	130	381	333	242
9-Mar	110	123	91	322	338	333
13-Mar	143	144	143	379	339	342
16-Mar	143	144	144	477	340	326
21-Mar	145	144	147	631	340	328
28-Mar	128	128	127	755	349	369
5-Apr	127	155	147	570	334	311
7-Apr	136	143	116	439	340	333
11-Apr	140	141	137	613	344	342
19-Apr	131	147	123	390	339	358
24-Apr	143	143	143	517	350	345
3-May	148	148	148	781		414
16-May				556	432	500
mean	**134**	**138**	**134**	**508**	**341**	**341**

During high flows in the Yolo Bypass in 2006 (Foe, personal communication, 12-2012). EC units are given in µS/cm

Transect sampling at ½ Lisbon will use each source water's chemical fingerprint to examine changes in MeHg production associated with the different water masses moving down the Yolo Bypass during flood events. Potentially, depending on the source water, MeHg processes may differ. For example, water quality associated with the Fremont Weir water is generally very low in total Hg, MeHg and TSS. Water quality associated with waters originating from Cache and Putah Creeks are very high in TSS, THg, and MeHg. These different water quality characteristics may result in different interactions between sediments and their associated MeHg. This study would take advantage of East-West gradients to determine which source water was the dominant contributor and help to further identify whether the major MeHg source is related to flow and resuspension or sediment-water exchange flux.

To capture the MeHg particulate and dissolved fingerprint of each water mass, we will collect samples along a transect at ½ Lisbon in order to capture the different water masses (if present). Depending on the extent of the flooding, approximately ten samples will be collected along the transect. Results from samples with similar Inductively Coupled Plasma (ICP) or ICP Mass Spectrometer (ICPMS) signatures will be averaged and considered to have originated from one of the four or five unique water masses that flow down the Yolo Bypass. The approximate location of the transect is shown in Figure 8. The transect is located at the lower portion of the Yolo Bypass where there is a natural elevation constriction. Sampling where there is a constriction is advantageous because the transect across the Yolo Bypass is shortest and therefore easier to sample MeHg and water flow. Additionally, on up to four transect sampling events, DWR hydrologists will determine flow and depth along the same transect so that flows and load can be calculated. To estimate loads, flow measurements during these four events will be extrapolated to the transect samples when flow is not measured.

5.7.3 Flow Measurements

Mass balance values will be calculated from concentrations collected from inlet/outlet samples and flow gauges installed on the major tributaries. The main sources of water during non-flood conditions are the Knights Landing Ridge Cut, and Cache and Putah Creeks. The main export point is the Toe Drain at Lisbon Weir. Flow measurements for Cache Creek can be obtained from the gauge at Yolo and for Putah Creek from the gauge at the town of Winters. Flow for the Knights Landing Ridge Cut can be estimated as the flow of the Colusa Basin Drain (CBD) near Knights Landing minus the flow of the CBD to the Sacramento River (CBD at Knights Landing gauge). CBD near Knights Landing flow can be estimated to be equal to the flow at the CBD at Highway 20 gauge, if no rain has occurred in the previous two days. If it rains, then the flow at the Highway 20 gauge is multiplied by 1.21 as recommended by the Yolo Bypass Working Group (2001). Flow at Fremont Weir will be obtained from the gauge at Fremont Weir. Flow at Lisbon Weir will be obtained from the gauge located at the Lisbon Weir.

For transect sampling south of the Lisbon Weir, flows will be calculated using an acoustic Doppler current profiler (ADCP) deployed with the boat during transect sampling. At the ½ Lisbon location, flow measurements would be collected up to 4X/sample year. Flow measurements during these four events will be extrapolated to the transect samples when flow is not measured.

5.7.4 Sample Collection

In the field, one team will sample Fremont Weir and ½ Lisbon by boat. Another team will sample Knights Landing Ridge Cut, the outlet from the CCSB and Putah Creek on land. A third team will conduct hydrology surveys at ½ Lisbon.

Samples will be collected and processed in one of the ways described below:

- Methodology 1: Samples will be collected in 4-liter (L) ichem 200 series bottles at each station. The filled bottles will be placed on ice and transported back to DWR's Bryte laboratory. In the laboratory, each sample will be portioned out of the 4-L bottle by shaking the bottle vigorously every five to ten seconds before pouring into bottles to be used for analyses. A peristaltic pump fitted with a cartridge filter will be used to filter dissolved samples. Using methodology that was developed in previous studies (Foe and others, 2008); the tubing will be acid cleaned to minimize the possibility of contamination. The MeHg samples will be preserved with reagent grade hydrochloric acid and kept cold and in the dark until they are shipped to Moss Landing Marine Labs (MLML) for analysis. The other samples will be preserved with standard methodologies for the analyses and kept at the DWR Bryte Lab until the samples are analyzed.
- Methodology 2: MeHg and Hg samples will be collected in the field in separate bottles. A 4-L polyethylene bottle will be used to collect samples for the other non-Hg and MeHg analytes. The MeHg samples will be shipped overnight to the laboratory at MLML. The dissolved MeHg water samples will be filtered in the laboratory using a standard 45 micron (µm), 47 Millimeter (mm) diameter filter that has been shown to be non-contaminating for MeHg. Total Hg will be filtered in the Bryte Laboratory using non contaminating 45 µm filters. The samples for the other analytes will be filtered in the laboratory at Bryte using standard methodologies. Quality assurance procedures are documented in Section 6.0 of this workplan.

5.7.5 Analytes Measured

Samples will be analyzed for THg (particulate and dissolved), MeHg (particulate and dissolved), total suspended solids,, volatile suspended solids, dissolved organic carbon, total nitrogen, nitrate plus nitrite, ammonia, dissolved organic nitrogen, total phosphate, orthophosphate, UVA254, Chlorophyll a, pH, Electrical Conductivity, temperature, and turbidity. For transect samples at ½ Lisbon, either ICP or ICPMS analyses for boron, calcium, lithium, magnesium and sodium will also be conducted on unfiltered, individual transect samples. If feasible, turbidity will also be measured continuously at all inlet and outlet sites. Field measurements will be made with YSI 6600 Sondes for temperature, salinity or EC, pH and turbidity or appropriate hand-held field instrumentation.

5.8 Sediment-Water Exchange and Particle Erosion Sampling Plan

As discussed in Appendix B, studies have shown that MeHg concentrations increase during flooding events as water flows down from the Upper Yolo Bypass. However previous studies have not determined if this increase in MeHg is a result of dissolved or particulate phase processes. If field studies find that MeHg production, during mini-flood events, is dominated by dissolved phase increases, then the relative importance of the dissolved phase as a source term for MeHg to the Yolo Bypass will be further investigated by using sediment-water flux exchange studies and wetting and drying flux exchange experiments. If our results find that the increases in MeHg are primarily associated with the particulate phase, then erosion experiments will be conducted to assess the relative importance of particle erosion and MeHg. If both processes are found to be important then, based on funding, a limited number of both dissolved and particulate phase experiments will be conducted.

The laboratory experiments outlined in the following subsections represent an optimum testing scenario. However, the DWR is currently funding all TMDL required open water studies as well as DWR TMDL studies associated with non-point source wetland control strategies, exposure reduction, and possible dredging work. Therefore, the proposed laboratory experiments may be subject to change to accommodate all DWR TMDL funding and scheduling responsibilities within the TMDL Phase 1 study period. It is anticipated that if costs need to be reduced, this would be done by reducing the number of test sites.

5.8.1 Dissolved MeHg Sediment-Water Exchange Studies

Sediment-water exchange laboratory studies will be conducted in phases, with the first phase providing an overview of MeHg flux rates by area. If funding is available, laboratory studies in Phase 2 will either expand the number of test sites or refine sediment flux processes observed in these laboratory experiments.

Release of MeHg from sediments could be the result of a number of factors including landscape features such as; type of plant cover or agriculture; the duration and frequency of wetting and re-wetting; water velocity and magnitude of flooding events; the Hg concentrations of source water; and the THg concentrations in sediments. A number of field and laboratory based approaches have been used to investigate the role of sediment water fluxes as a source of MeHg to overlying waters (Mitchell and others 2012; Hammerschmidt and others 2004, Hollweg and others 2009, 2010, Gill and others, 2003, and Gill, 2008). A limited number of studies have also been conducted within the Delta (e.g., Choe and others, 2004; and Hiem and others, 2007). The Workgroup proposes similar approaches to investigate the role of sediments as an internal source of MeHg to the Yolo Bypass.

5.8.2 Flux rates based on soils and land use type

The goal of the first phase of these laboratory studies will be to define sediment flux rates from as many different soil and land uses as possible. Flux rates would be provided to the D-MCM model. If feasible, Phase 2 laboratory experiments would focus on defining the mechanisms behind Phase 1 processes. This approach ensures that even if funding is unavailable to conduct Phase 2 laboratory studies, the Hg model could still predict the relative MeHg production impacts due to inundation of different land uses or soil types.

To determine sample locations, aerial photographs or maps showing land use or land type will be examined to determine the location of different crop types, land uses, and vegetation types in the Yolo Bypass. Some of the needed information may already be available as part of the deliverables of the Non-Point Source MeHg Workgroup (for example, see Figure 9, Figure 10, and Figure 11). The Non-Point Source MeHg Workgroup produced GIS layers of major crops planted in the Yolo Bypass. The Workgroup proposes to initially use this information to select sampling locations based on different plant covers, crop types, and land use management. Heim and others (2003) have also identified sediment hot spots in the Yolo Bypass that shows the spatial heterogeneity of Hg distribution in Yolo Bypass soils.

Based on land use and soil type characteristics, and funding considerations, sediment cores will be collected in triplicate on up to 12 different locations in the Yolo Bypass. The final number of land uses tested would be determined by landowner permission, access, and experimental costs, and if erosion experiments were also being conducted (see below). The six-inch intact sediment cores would be collected in late fall prior to the first rain event. The dry cores will be sent to the MLML for experimental setup. Cores will be overlain with Sacramento River water. Sediments will be held at constant temperature. Water will be agitated gently by slowly bubbling ambient air to eliminate any stagnant layers from forming as well as hypoxic conditions. Filtered samples of the overlying water will be collected at approximately six to eight time points (e.g., 0, 2, 4, 8, 12, 16, and 21 days) and analyzed for dissolved THg and MeHg. The mass of MeHg diffusing into the overlying water will be calculated based on concentrations of MeHg in the overlying water over the experimental period.

5.8.3 Flux rates based on flooding cycles

The goal of these laboratory experiments will be to mimic the flooding frequency and duration experienced by sediments in the Yolo Bypass and provides these as rate constants to the D-MCM model. Flooding scenarios in the Yolo Bypass generally fall into one of two categories—several mini flood events, with source water overtopping the banks of one or more tributaries to the Yolo Bypass, or large flooding events where overtopping of the Fremont Weir by the Sacramento River results in a major flooding event that can last for several months.

The Workgroup proposes to mimic two mini floods and one major flood event in the laboratory. Three replicate cores from a vegetated area and a non-vegetated area will be collected. To simulate two consecutive mini flood events, cores will be overlain with Sacramento River water for two weeks, then drained and kept moist for one month. The moisture content of the sediments in the Yolo Bypass will be measured monthly. The moisture content of soils held in the laboratory will be adjusted accordingly to reflect the moisture content in the field. After being held for one month, the experiment will be repeated to simulate a second mini-flood event. Following the two mini-flood event cycles, the cores will be overlain with Sacramento River water and held for two months. Water levels will be drained and replenished at weeks three and six.

Analyses would be similar to sediment flux rate experiments. For experiments simulating mini-flood events, dissolved THg and MeHg will be collected and analyzed by MLML at approximately six to eight time points over each two week flood period (e.g., 0,2,4,8,12,and 14 days). For experiments simulating a large flooding event, dissolved THg and MeHg will be collected and analyzed by MLML at set time points (e.g., 0, 2, 4, 8, 12, 16, 21 days). To account for evaporation, at week's three and six, cores would be topped off with Sacramento River water to the original time zero depth. Samples would again be collected at set time points (e.g., 0, 2, 4, 8, 12, 16, 21 days) to continue to monitor the sediment flux under long-term inundation.

5.8.4 Particulate MeHg Studies

The goal of the particulate phase studies will be to determine sediment erosion rates for the D-MCM model to relate soil or land use type to MeHg production. Since water velocities and erosion rates of particulates in the Yolo Bypass are expected to vary substantially over time and space, erosion rates will be determined on up to 12 land uses or soil types in the Yolo Bypass. Three replicate cores will be collected at each location. Phase 2 laboratory experiments would focus on examining the relationship between MeHg production and erosion from additional sample sites.

Erosion rate measurements will be determined following the methodology outlined by Roberts and Jepsen, 2004. Briefly, a closed loop recirculating system will be used to recirculate water over the top of a core sample at several different flow velocities. A recirculating pump will be used to create a known velocity. Turbidity will be measured continuously. Particulate and dissolved THg, MeHg and TSS will be collected from the overlying water column at three time points; time 0, ~15 minutes and time "x," where x represents, for a given velocity, the amount of time it takes water to travel from the Fremont Weir to the stairsteps near the end of the Yolo Bypass. A total of three velocities will be tested. Velocities will correspond to several different flooding event scenarios. All analyses will be conducted by MLML. Additionally, sediment bound THg and MeHg will be measured in a separate replicate core, at two centimeter increments (up to three increments).

Regression relationships developed between TSS and velocity and velocity and particulate and dissolved THg and MeHg will be used to provide the D-MCM model with rate constants that relate flow and erosion to THg and MeHg production.

5.9 Application of Current Cache Creek Settling Basin Studies to Areas Outside the Yolo Bypass

The DWR is also funding studies with the USGS and U.C. Davis in the CCSB. The Department is responsible for the operation and maintenance of the CCSB in Yolo County. The CCSB acts as a sediment trap by capturing the flashy storm flows from Cache Creek and allowing the sediment to settle before exiting into the Yolo Bypass. There is considerable interest in the CCSB from the CVRWQCB as a place where potentially significant load reductions of Hg and MeHg may be achieved. Although the CCSB traps much of the total THg from Cache Creek, it is unknown how effective the CCSB is in trapping MeHg. There is also concern that seasonal wetlands and agricultural fields within the CCSB are areas where Hg is methylated such that there may actually be a net increase of MeHg loads as Cache Creek passes through the CCSB rather than a net removal from particle settling, as is the case with THg. In addition, potential future excavation in the CCSB to improve trapping efficiency might expose sediment with higher THg, possibly leading to higher MeHg.

Beginning in 2008, DWR contracted with the USGS and U.C. Davis to conduct studies to improve the flow and sediment record for the inflow to and the outflows from the CCSB. The approach to the Hg studies employs both standard monitoring activities and supporting research efforts. The monitoring activities are designed to address the need for high quality flow, velocity, and sediment load data whereas the research efforts are designed to address data gaps that may affect DWR's ability to manage the CCSB to reduce loads of THg and MeHg.

The Workgroup will work with these entities to evaluate if any of the results or findings can be applied to the Yolo Bypass as a system. Where applicable, results of these collaborative studies will be applied to the Workgroup's efforts to model and understand MeHg processes and landscape interactions in the Yolo Bypass. Current collaborative studies are quantifying loading into and out of the CCSB during storm and non-storm events. If applicable, the Workgroup will use this information as an input term for the Hg cycling model. The sensitivity of the system to changes in CCSB discharge will be examined by using the D-MCM and Yolo Bypass model and varying the load exiting the basin into the Yolo Bypass. Results of this exercise should provide an estimate of the load reduction required to influence MeHg production in the Yolo Bypass.

Collaborative studies will also focus on the spatial and temporal differences of water-borne and bed sediment MeHg and MeHg/THg concentrations between different crops and riparian areas found in the CCSB. Results of these studies may provide information that can be extrapolated to similar land uses in the Yolo Bypass and provide further information to support or refute laboratory studies of MeHg diffusive flux from soils associated with different crop types or agricultural practices.

5.10 Schedule

The schedule shown in Figure 12 provides approximate timelines for completion of Phase 1 of the workplan. It encompasses two years of inlet/outlet and transect sampling (up to 12 sampling events under mini and normal flood flows plus four flow transects/year) and laboratory studies in the 2nd sampling year.

5.11 Budget

Approximate costs for Phase 1 of this workplan are provided below. Phase 2 costs cannot be estimated until the results or direction, provided by Phase 1 studies, has been determined.

Table 4. Budget

Item	FY 12/13	FY 13/14	FY 15/16	FY 16/17	FY 17/18	Total
Project Management	62	31	62	31	62	**248 K**
Workplan Preparation	272					**272 K**
Modeling	3	100	100	TBD	TBD	**203 K**
DWR Bay Delta Office Modelers	30	100	100	TBD	TBD	**230 K**
Inlet/Outlet Grab and Transect Studies (Labor and MLML analytical costs)	35	105	105			**245 K**
Flux Laboratory Studies (land-use & flooding events)(MLML analytical costs)			145			**145 K**
Erosion Laboratory Studies (MLML analytical costs)			261			**261 K**
Bryte Laboratory		16	16			**32 K**
Report Production			247		495	**742 K**
Sum	**402 K**	**352 K**	**1036 K**	**31 K**	**557 K**	**2378 K**

If all studies could be conducted as detailed in this workplan, the approximate cost would be approximately 2.4 million. The Regional Board estimated that the cost to conduct open water studies ranged between $900,000 to $1.3 million (CVRWQCB, 2010). Projected costs would be greater if funding was available to move forward with proposed Phase 2 open water studies. The budget outlined above represents a best case scenario and assumes that all studies proposed in this study can be funded. However, in most study years, these costs exceed DWR’s combined budget for open water, tidal wetlands, exposure reduction and dredging TMDL requirements. Therefore, as discussed earlier, the proposed open water field and laboratory sampling and scheduling may be subject to change to accommodate all DWR TMDL funding and scheduling responsibilities within the TMDL Phase 1 study period. The Workgroup will continue to pursue other avenues of funding to supplement the DWR's funding.

6.0 QUALITY ASSURANCE PROCEDURES

The objective of data collection for this study is to produce data that are representative of actual field conditions of the Delta and Yolo Bypass as they relate to existing levels of THg and MeHg. This objective will be met by using accepted methods to collect and analyze samples for precision, accuracy, comparability, representativeness, and completeness. Methods used are as follows.

1. Sample collection will follow the CALFED Bay-Delta Program (CALFED) Mercury Project Quality Assurance Project Plan guidelines; including the US EPA Method 1669 for clean hands/dirty hands technique (Puckett and van Buuren, 2000).
2. Sample analysis of MeHg will follow the MLML modifications of US EPA Method 1630 with a method detection limit of 0.02 ng/L or less.
3. Sample analysis of THg and all other constituents will follow Bryte Chemical Laboratory's quality assurance manual (note that the current version lists US EPA Method 245.1 and 200.8 for Total Hg analysis, but it is not completely up to date; US EPA Method 1631 Revision E will be used with a method detection limit of 0.2 ng/L or less) (DWR, 2012).
4. Sample tracking, data archiving, and data retrieval will follow the DWR Field and Laboratory Information Management System (FLIMS) guidelines and stored on DWR's Water Data Library (WDL).
5. 10% of samples analyzed will be for the purpose of evaluating analytical accuracy. A field blank and a field duplicate will be submitted with every 20th sample or for every batch of samples from a single collection event, whichever is less. A laboratory duplicate will be analyzed according to MLML or Bryte Laboratory protocols.
6. Mercury model calibration will follow the scope of work outlined by the contracted mercury modeler.

7.0 PROJECT EVALUATION AND DATA SHARING PLAN

7.1 Proposed Data Collection

The modeling process is subdivided into two phases. Phase 1 will be conducted using current projected funding, while Phase 2 will be conducted pending securing additional funding. Phase 1 consists of creating and validating conceptual models for Hg drivers in the Delta and the Yolo Bypass and integrating a mercury cycling model into a hydrodynamic models for the Delta (DSM2). Since hydrodynamic models are still in the development phase, the D-MCM will be used to examine flood management scenarios for the Yolo Bypass. Water quality and mercury process data already exists for some sections of the Delta. The Workgroup believes these data are sufficient to begin the creation of an Hg screening model for the Delta. Additionally rate constants from the literature will be used in the integration between DSM2 and the mercury cycling model. Limited data, however, exists for the Yolo Bypass. Therefore, the Yolo Bypass Hg model will rely on rate constant data from the literature. In parallel spatial and temporal biogeochemical process rate data will be collected to create mercury rate constants encompassing different seasons and years. It is anticipated that data collection would occur over two years. The sensitivity analyses will be used in both the Delta and Yolo Bypass models to determine the impact of changes to different drivers to the system. If model development is successful, the models will also be used to examine the impact of potential water management and flood management changes to the system.

If funding is available, Phase 2 will focuses on model refinements, filling in data gaps identified in Phase 1, and reexamining the impacts of various proposed water management strategies. Phase 2 is based on funding and time constraints. However, even if funding precludes robust Phase 2 scenario testing, Phase 1 sensitivity analyses will provide the CVRWQCB and the scientific community with a better understanding of the driving forces controlling MeHg in the Delta and Yolo Bypass (e.g., atmospheric deposition, bioaccumulation, flow, sediment flux) and allow the CVRWQCB to prioritize and focus future actions.

Data collected to support the model are described in Section 5.0 and will follow the Quality Assurance/Quality Control Plan described in Section 6.0. Data will be posted to DWR's WDL, including quality assurance data. The website is located at http://www.water.ca.gov/waterdatalibrary and data are available to the public. Data analyzed by DWR's Bryte Laboratory and MLML's data will be entered into Bryte's FLIMS database to be uploaded to the WDL. The DSM2 model with Hg cycling algorithms embedded is an open source model and freely available to the public. Similarly, the D-MCM will be publically available, however the source code in the D-MCM cannot be altered.

7.2 Control Measure Effectiveness

Calibration and validation of the model provides a mechanism to examine the model's effectiveness to accurately predict and evaluate MeHg drivers, and operational changes to the open water and flood conveyance systems. Incorporation of the Hg cycling processes into DSM2 will provide full hydrodynamic understanding of loading and load allocations under different operational scenarios or sensitivity analyses. Use of the D-MCM for the Yolo Bypass can still be used to understand how changes in flood management operations could impact MeHg production in the Yolo Bypass. Without a full hydrodynamic model, D-MCM will be run under different sets of inundation patterns and frequencies to simulate the effects of notching of the Fremont Weir.

One goal of this process is to create an open source model that can be made available to interested parties. Creation of this tool moves beyond the effectiveness of a single control strategy and encompasses a mechanism that allows numerous hypotheses and process questions to be examined by the community at large.

7.3 Cost Estimates

The cost of developing Phase 1 modeling and conducting Phase 1 experiments is given in Table 4. This estimate includes the following items: contract with modeling expert, DWR staff time, data gathering, report preparation, implementation (e.g., running the model to test various operational or physical scenarios), project management, etc. Section 5.0 also contains a proposed schedule for Phase 1 activities.

As detailed earlier, creating control measures for the operation of the State and Central Valley projects as well as controlling flood waters is extremely difficult with operations subject to numerous regulations by State and Federal agencies. Unless funding can be secured to conduct a full economic analysis of the costs to the State, the final report will focus on identifying the changes to loads under different operational scenarios while leaving actual cost analysis to the legislative, congressional, or other oversight agencies (e.g., NMFS or ratepayers like State Water Contractors) that will be required to grant authority to implement. Estimate of these costs will be outside the scope of this workplan and the final report.

7.4 Potential Environmental Impacts

Development and use of the model will have no impact on humans, wildlife, or the environment. Data gathering will be conducted in the field, but is not expected to result in any significant environmental impacts. If a model can be developed that is capable of providing accurate predictions of the effects of changes to the operational or physical characteristics of the SWP, CVP, and flood conveyance systems there is the potential for positive environmental effects (e.g., reduced levels of MeHg) to be realized through the application of knowledge derived from modeling to real world decisions affecting project operations or improvements.

7.5 Overall Feasibility of Implementation

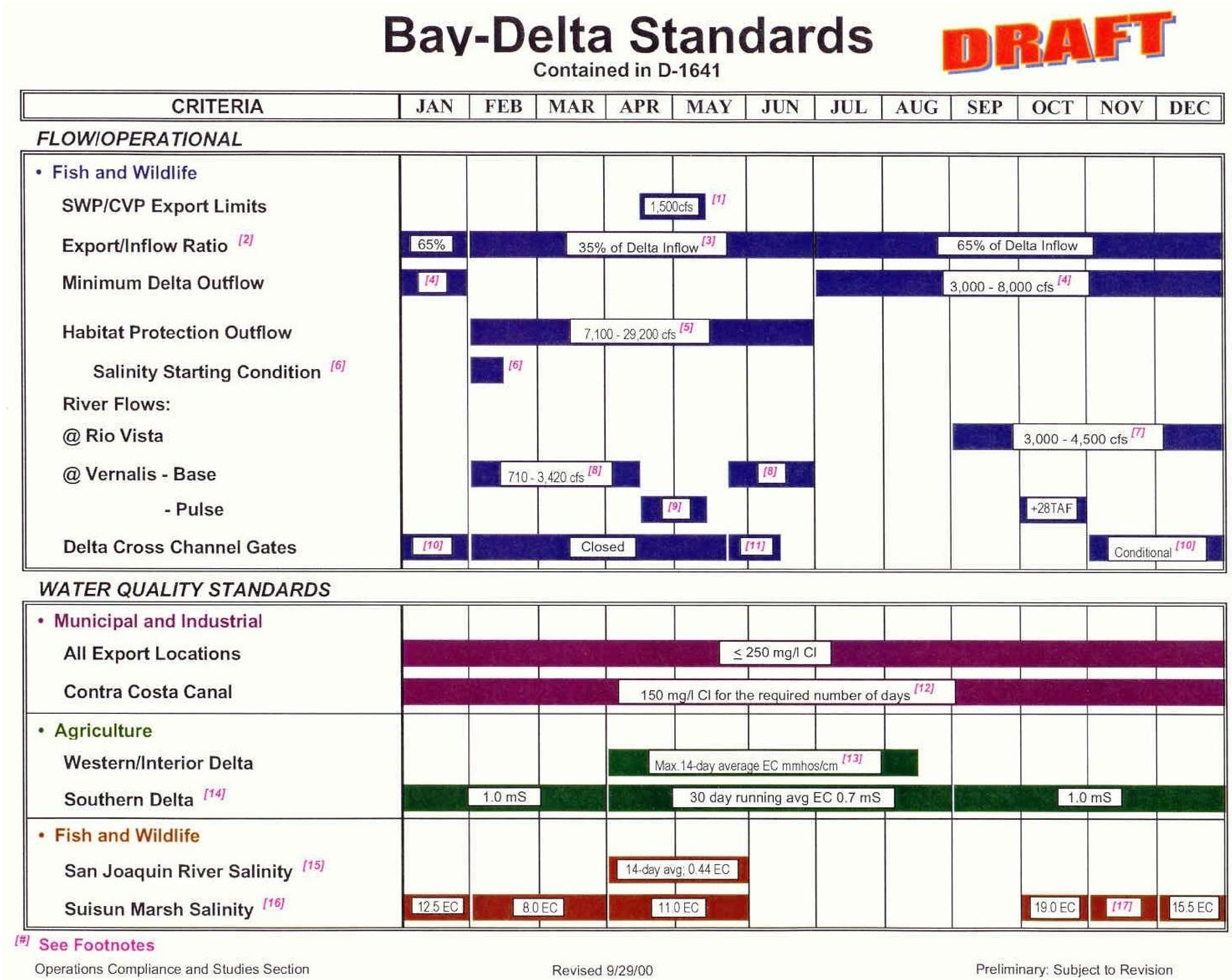
Development of a Delta and Yolo Bypass open water and flood conveyance mercury model has never been attempted. Nevertheless, a model of this type has been described by the

CVRWQCB's Technical Advisory Committee as "one of the most important outcomes of the Phase 1 Hg TMDL process." Successful completion of Phase 1 modeling will serve as an endpoint and a foundation for integrating and understanding MeHg dynamics in open waters of the Delta and the Yolo Bypass which will lead to recommendations, and possibly the need to examine currently unexplored questions illuminated by the model. However, any implementation of a recommendation from the Workgroup's final report will require implementation within the regulatory framework outlined in Section 1.0 that governs water and flood management operations in the Delta and Yolo Bypass (e.g., D-1641 or the Biological Opinions). While not covered in the Delta TMDL, water operations and water quality are also greatly impacted by upstream reservoir operations. Given this framework, implementation may require the participation of legislative, congressional, or other oversight agencies (e.g., NMFS) or ratepayers to implement. Taken together, these limitations severely constrain any changes in water management operations in the Delta and Yolo Bypass. However, in areas where the Workgroup has jurisdiction (e.g., the CSLC's ability to control lease activities on State lands), the Workgroup will provide input on the feasibility of implementing any recommendations documented in the final report. Furthermore, recommendations on possible future regulatory proposals may be useful to CVRWQCB staff to prioritize and focus future actions.

8.0 SUPPORTING FIGURES

Figure 1. Partial List of D-1641 Regulatory Criteria Guiding State Water Project Operations

(Accessed 12/16/12, http://www.water.ca.gov/swp/operatioscontrol/docs/bay_deltastandards.htm)



Footnotes

[1] Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping.

Year Type	All
Apr15-May15*	The greater of 1,500 or 100% of 3-day avg. Vernalis flow

* This time period may need to be adjusted to coincide with fish migration. Maximum export rate may be varied by CaiFed Op's group.

[2] The maximum percentage of average Delta inflow (use 3-day average for balanced conditions with storage withdrawal, otherwise use 14-day average) diverted at Clifton Court Forebay (excluding Byron-Bethany pumping) and Tracy Pumping Plant using a 3-day average. (These percentages may be adjusted upward or downward depending on biological conditions, providing there is no net water cost.)

[3] The maximum percent Delta inflow diverted for Feb may vary depending on the January SRI.

Jan SRI	Feb exp. limit
≤ 1.0 MAF	45%
between 1.0 & 1.5 MAF	35%-45%
> 1.5 MAF	35%

[4] Minimum monthly average Delta outflow (cfs). If monthly standard ≤5,000 cfs, then the 7-day average must be within 1,000 cfs of standard; if monthly standard >5,000 cfs, then the 7-day average must be ≥80% of standard.

Year Type	All	W	AN	BN	D	C
Jan	4,500*					
Jul		8,000	8,000	6,500	5,000	4,000
Aug		4,000	4,000	4,000	3,500	3,000
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

* Increase to 6,000 if the Dec SRI1s greater than 800 TAF

[5] Minimum 3-day running average of daily Delta outflow of 7,100 cfs OR: either the daily average or 14-day running average EC at Collinsville is less than 2.64 mmhos/cm (This standard for March may be relaxed if the Feb SRI is less than 500 TAF. The standard does not apply in May and June if the May estimate of the SRI is < 8.1 MAF at the 90% exceedence level in which case a minimum 14-day running average flow of 4,000 cfs is required.) For additional Delta outflow objectives, see TABLE A.

[6] February starting salinity: If Jan SRI >900 TAF, then the daily or 14-day running average EC at Collinsville must be ≤ 2.64 mmhos/cm for at least one day between Feb 1-14. If Jan SRI is between 650 TAF and 900 TAF, then the CalFed Op's group will determine if this requirement must be met.

[7] Rio Vista minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 1,000 below the monthly objective).

Year Type	All	W	AN	BN	D	C
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

[8] BASE Vernalis minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 20% below the objective). Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Feb-Apr14 and May16-Jun		2,130 or 3,420	2,130 or 3,420	1,420 or 2,280	1,420 or 2,280	710 or 1,140

[9] PULSE Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be at or west of Chipps Island.

Year Type	All	W	AN	BN	0	C
Apr15-May15		7,330 or 8,620	5,730 or 7,020	4,620 or 5,480	4,020 or 4,880	3,110 or 3,540
Oct	1,000					

* Up to an additional 28 TAF pulse/attraction flow to bnng flows up to a monthly average of 2,000 cfs except for a critical year following a critical year. Time period based on real-time monitoring and determined by CaiFed Op's group.

[10] For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days.

[11] For the May 21-June 15 period, close Delta Cross Channel gates for a total of 14 days per CALFED Op's group. During the period the Delta cross channel gates may close 4 consecutive days each week, excluding weekends.

[12] Minimum # of days that the mean daily chlorides ≤150 mg/l must be provided in intervals of not less than 2 weeks duration. Standard applies at Contra Costa Canal Intake or Antioch Water Works Intake.

Year Type	W	AN	BN	D	C
# Days	240	190	175	165	155

[13] The maximum14-day running average of mean daily EC (mmhos/cm) depends on water year type.

	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R @ Terminous		SJR @ San Andreas	
Year Type	0.45 EC from April 1 to date shown	EC value from date shown to Aug15*	0.45 EC from April 1 to date shown	EC value from date shown to Aug15*	0.45 EC from April 1 to date shown	EC value from date shown to Aug15*	0.45 EC from April 1 to date shown	EC value from date shown to Aug15*
W	Aug 15		Aug 15		Aug 15		Aug 15	
AN	Jul 1	0.63	Aug 15		Aug 15		Aug 15	
BN	Jun 20	1.14	Jun 20	0.74	Aug 15		Aug 15	
D	Jun 15	1.67	Jun 15	1.35	Aug 15		Jun 25	0.58
C		2.78		2.20		0.54		0.87

* When no date 1s shown, EC limit continues from April 1.

[14] As per D-1641, for San Joaquin River at Vernalis: however, the April through August maximum 30-day running average EC for San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridge shall be 1.0 EC until April 1, 2005 when the value will be 0.7 EC.

[15] Compliance will be determined between Jersey Point & Prisoners Point.
Does not apply in critical years or in May when the May 90% forecast of SRI ≤8.1 MAF.

[16] During deficiency period, the maximum monthly average mhtEC at Western Suisun Marsh stations as per SMPA is:

Month	mhtEC
Oct	19.0
Nov	16.5
Dec-Mar	15.6
Apr	14.0
May	12.5

[17] In November, maximum monthly average mhtEC = 16.5 for Western Marsh stations and maximum monthly average mhtEC = 15.5 for Eastern Marsh stations in all periods types.

Number of Days When Max. Daily Average Electrical Conductivity of 2.64 mmhos/cm Must Be Maintained at Chipps Island and Port Chicago. (This can also be met with a maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago Standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mmhos/cm or less. PMI is previous month's SRI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of day's for values of the PMI between those specified below shall be determined by linear interpolation.

PMI	Chipps Island (Chipps Island Station D10)				
(TAF)	FEB	MAR	APR	MAY	JUN
≤500	0	0	0	0	0
750	0	0	0	0	0
1000	28*	12	2	0	0
1250	28	31	6	0	0
1500	28	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
≥5500	28	31	30	31	30

* When 800 TAF < PMI < 1000 TAF, the number of days is determined by linear interpolation between 0 and 28 days.

Port Chicago

PMI	(continuous recorder at Port Chicago)				
(TAF)	FEB	MAR	APR	MAY	JUN
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1000	12	4	0	0	0
1250	15	6	1	0	0
1500	18	9	1	0	0
1750	20	12	2	0	0
2000	21	15	4	0	0
2250	22	17	5	1	0
2500	23	19	8	1	0
2750	24	21	10	2	0
3000	25	23	12	4	0
3250	25	24	14	6	0
3500	25	25	16	9	0
3750	26	26	18	12	0
4000	26	27	20	15	0
4250	26	27	21	18	1
4500	26	28	23	21	2
4750	27	28	24	23	3
5000	27	28	25	25	4
5250	27	29	25	26	6
5500	27	29	26	28	9
5750	27	29	27	28	13
6000	27	29	27	29	16
6250	27	30	27	29	19
6500	27	30	28	30	22
6750	27	30	28	30	24
7000	27	30	28	30	26
7250	27	30	28	30	27
7500	27	30	29	30	28
7750	27	30	29	31	28
8000	27	30	29	31	29
8250	28	30	29	31	29
8500	28	30	29	31	29
8750	28	30	29	31	30
9000	28	30	29	31	30
9250	28	30	29	31	30
9500	28	31	29	31	30
9750	28	31	29	31	30
10000	28	31	30	31	30
> 10000	28	31	30	31	30

Figure 2. Partial List of Biological Opinion Reasonable and Prudent Actions Governing SWP Operations

(All SWP and Yolo Bypass Reasonable and Prudent Actions can be accessed at the NMFS website http://swr.nmfs.noaa.gov/)

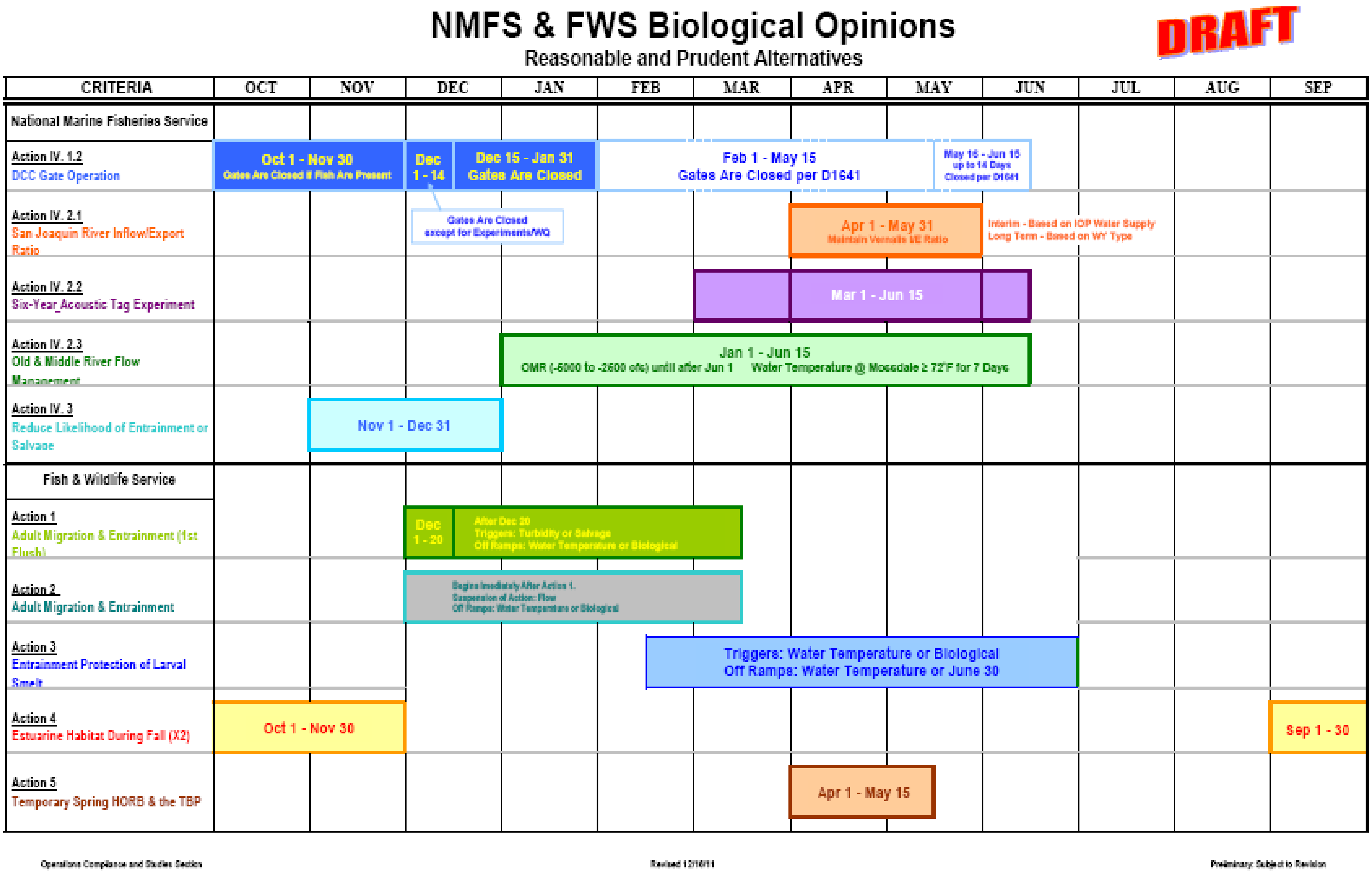


Figure 3. Update of Methyl mercury Mass Balance Model for the Delta

(Presented in CVRWQCB., 2010)

The revised model incorporates both some new rates for previously measured terms (tributary inputs and exports to southern California and San Francisco Bay) and rates for two previously unmeasured processes, photo demethylation and sedimentation.

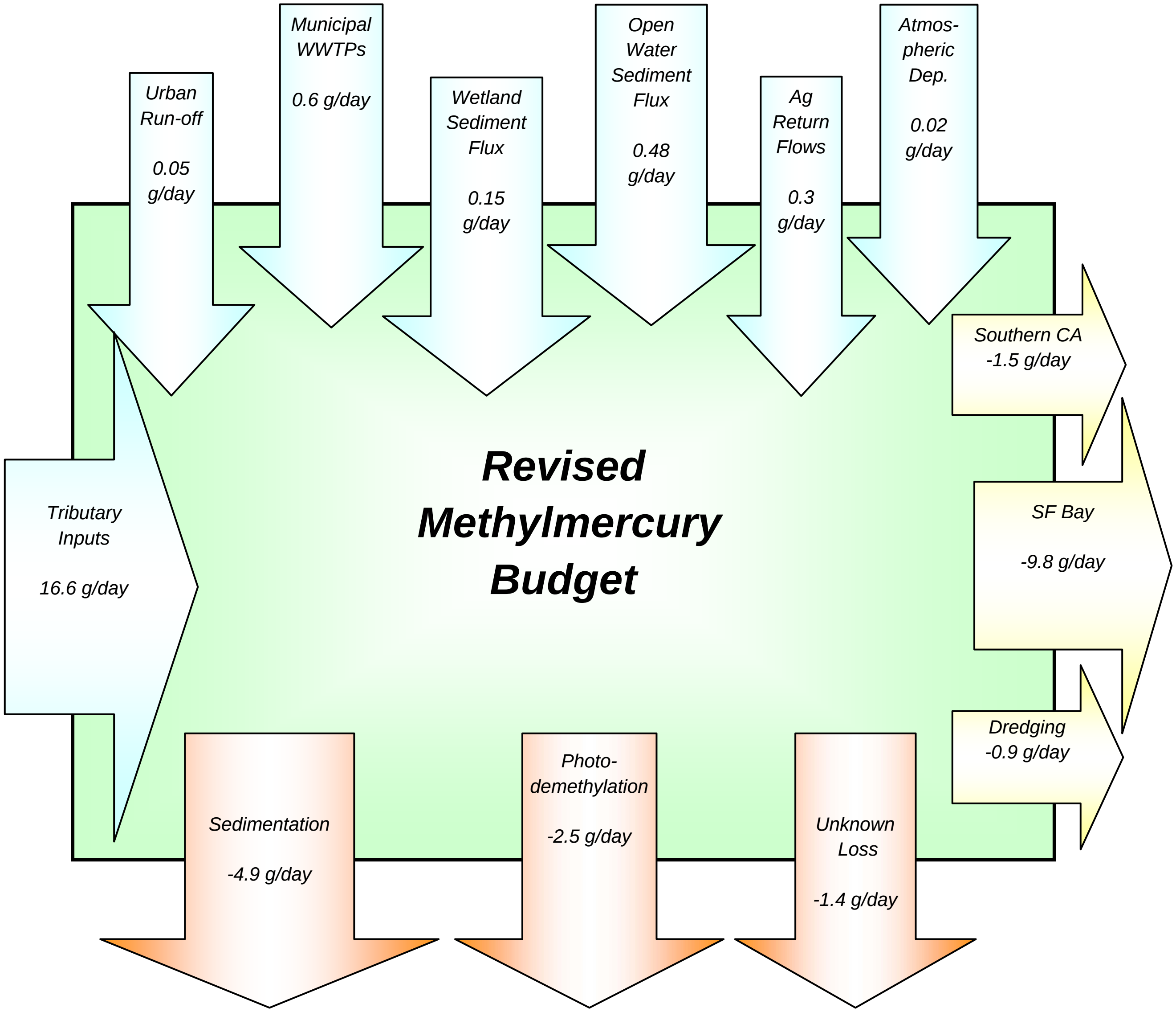


Figure 4. Conceptual Model for Unfiltered MeHg in the Yolo Bypass During Mini Floods < 5000 cfs

(Data from Foe and others, 2008)

Data presented are an average of the mini flood events from year 2005.

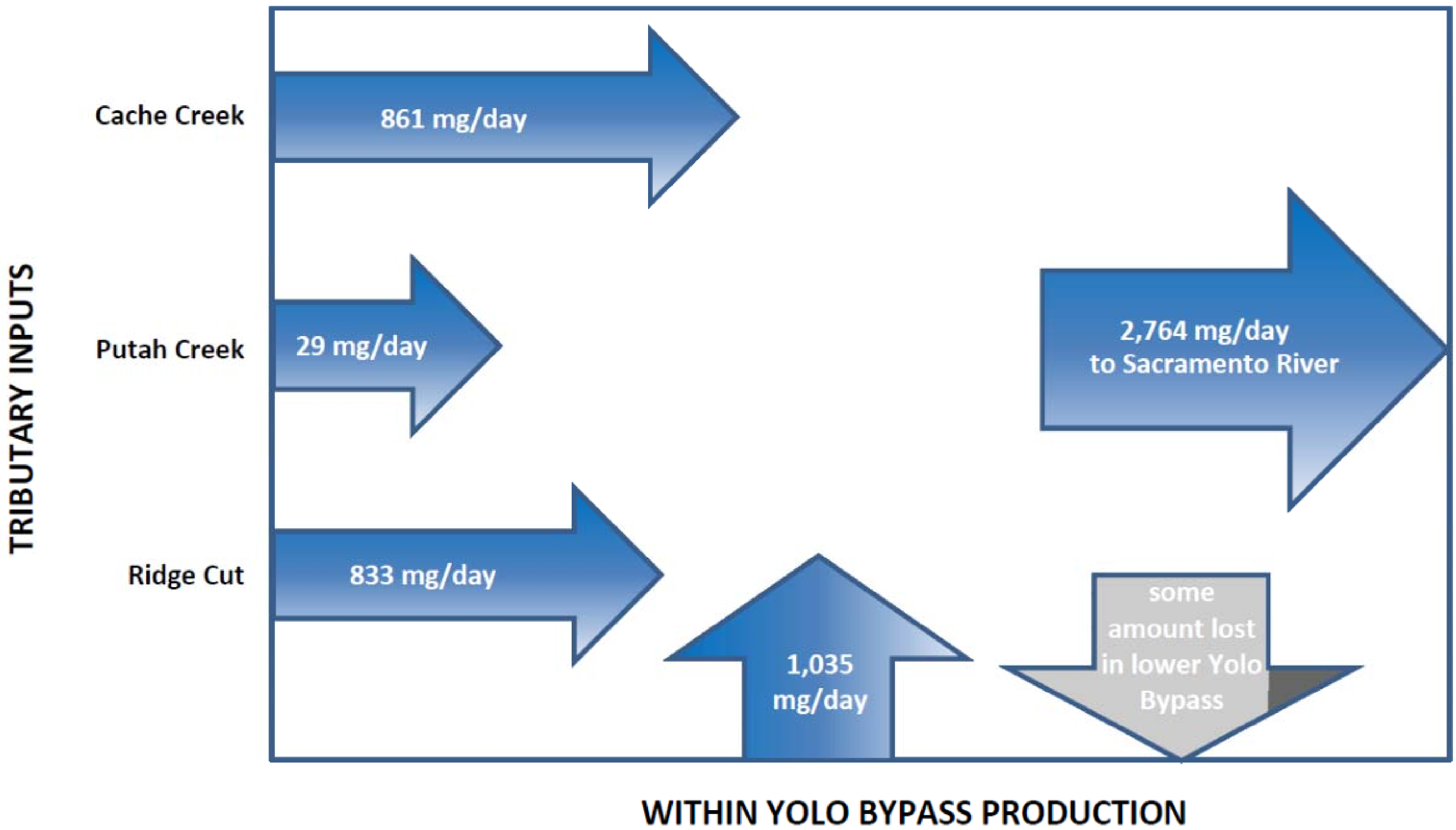


Figure 5. Conceptual Diagram of Hg Cycling and Bioaccumulation in Aquatic Systems

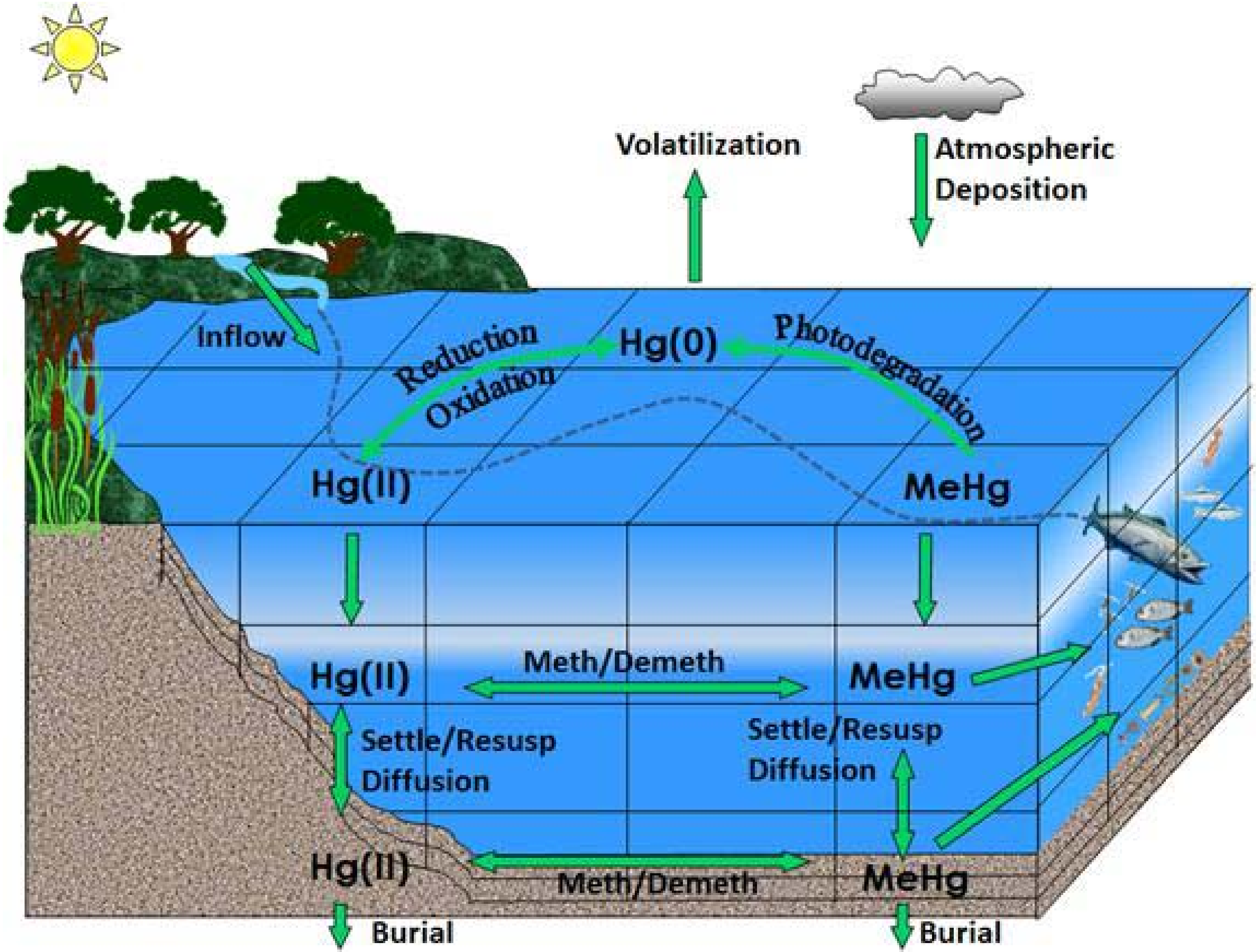


Figure 6. Proposed Location of Inlet/Outlet Sampling Stations and East-West Transect

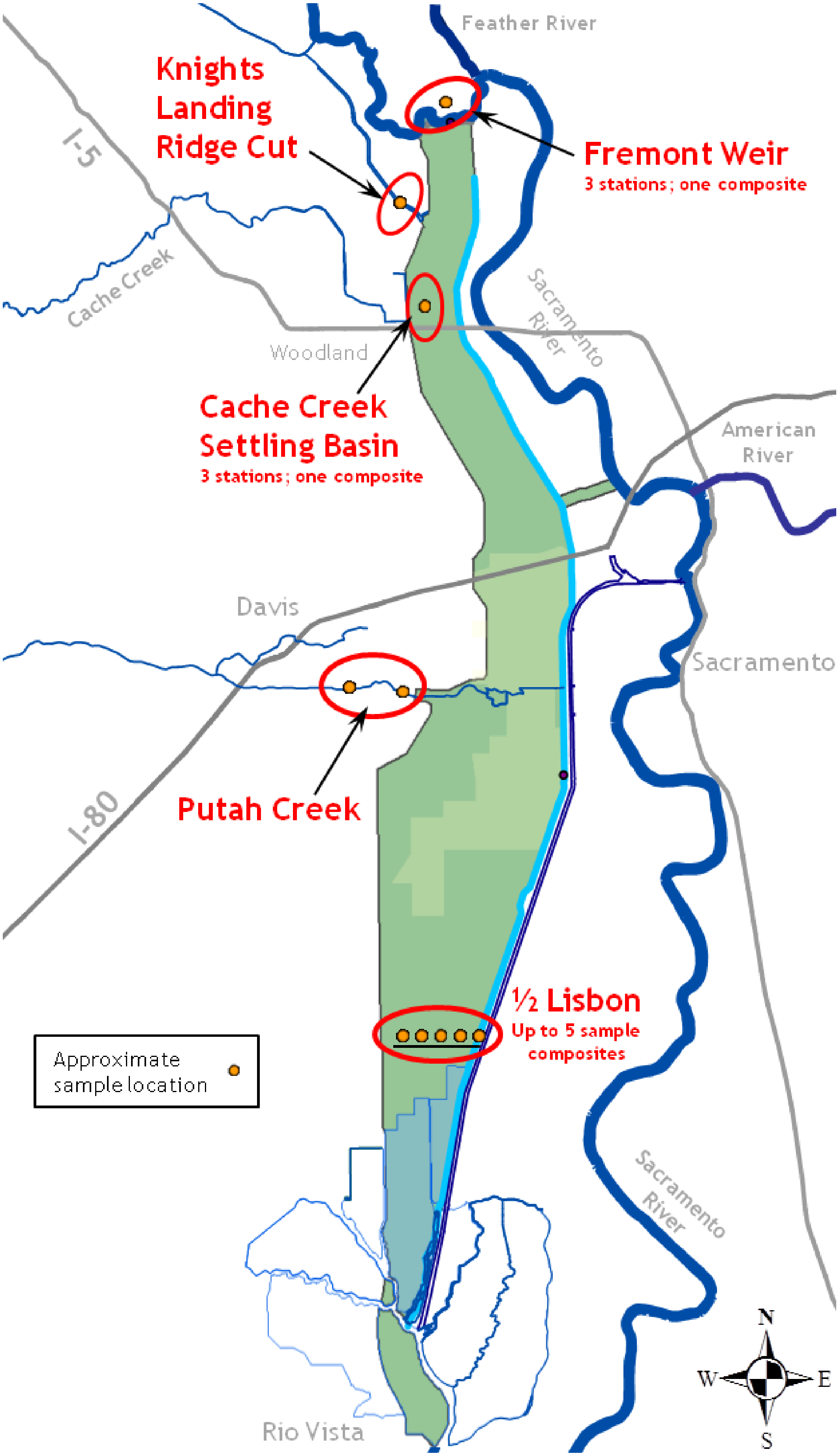


Figure 7. Higher Resolution Photomosaic of the Central 10 km of the Yolo Bypass

(From Sommer and others, 2007)

Figure 8. Location of ½ Lisbon Weir on Elevation Map of Yolo Bypass

Deepest areas are shown in blue. Shallowest areas are shown in red.

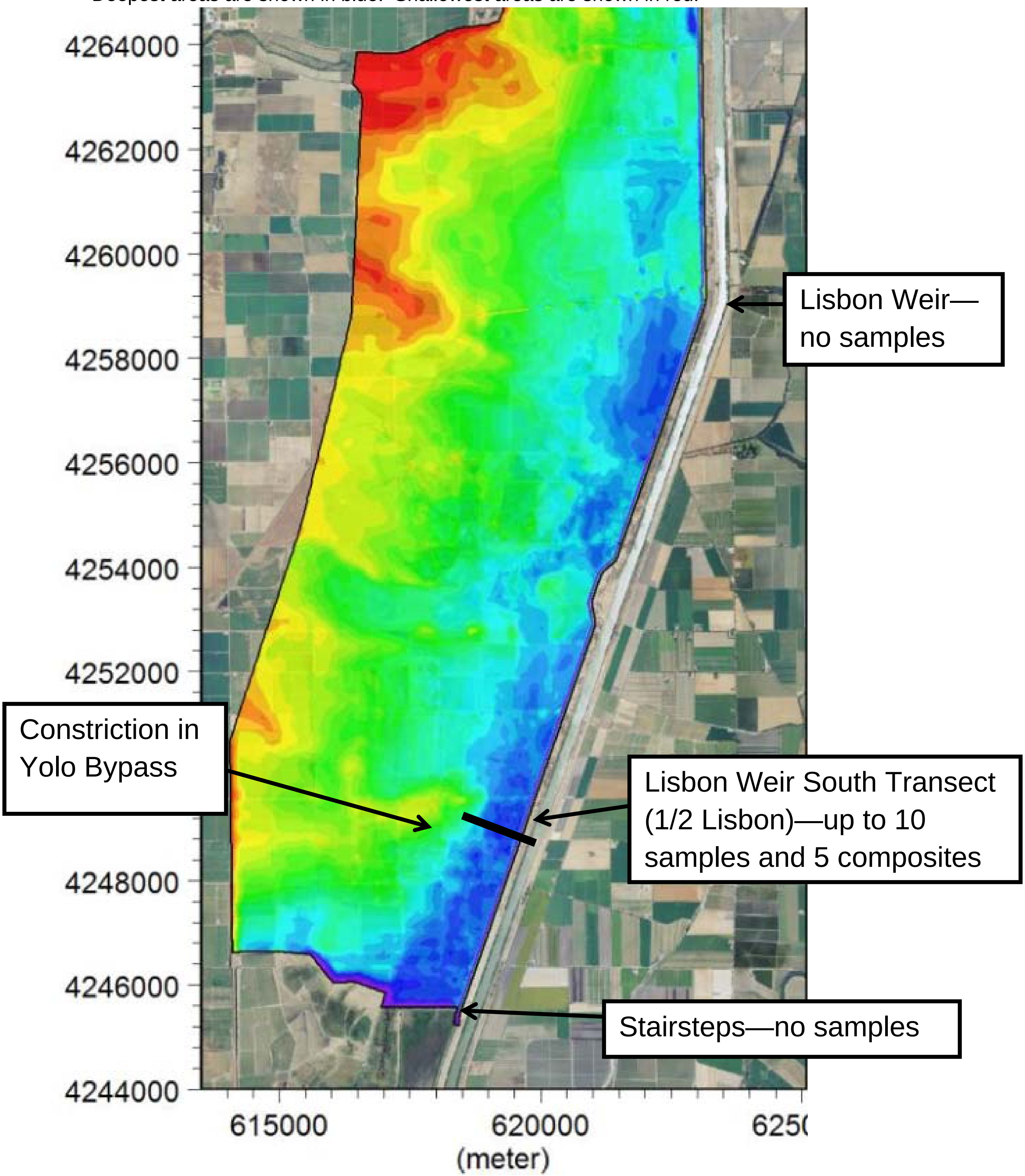


Figure 9. Map of Major Agricultural Types in the Delta and Yolo Bypass

(From Petrik, 2012)

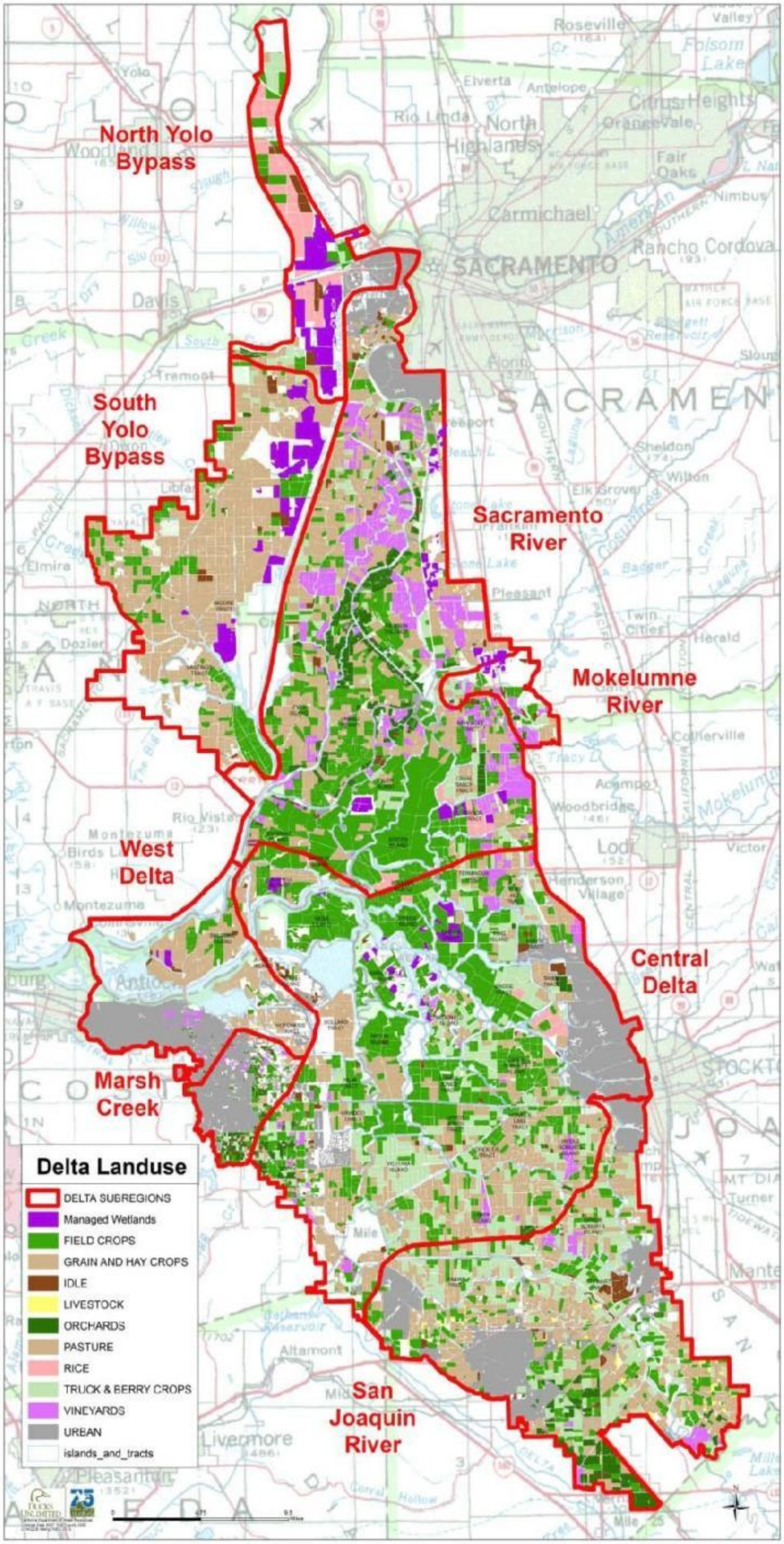


Figure 10. Map of the Distribution of Specific Crops within the Field Crop Category

(From Petrik, 2012)

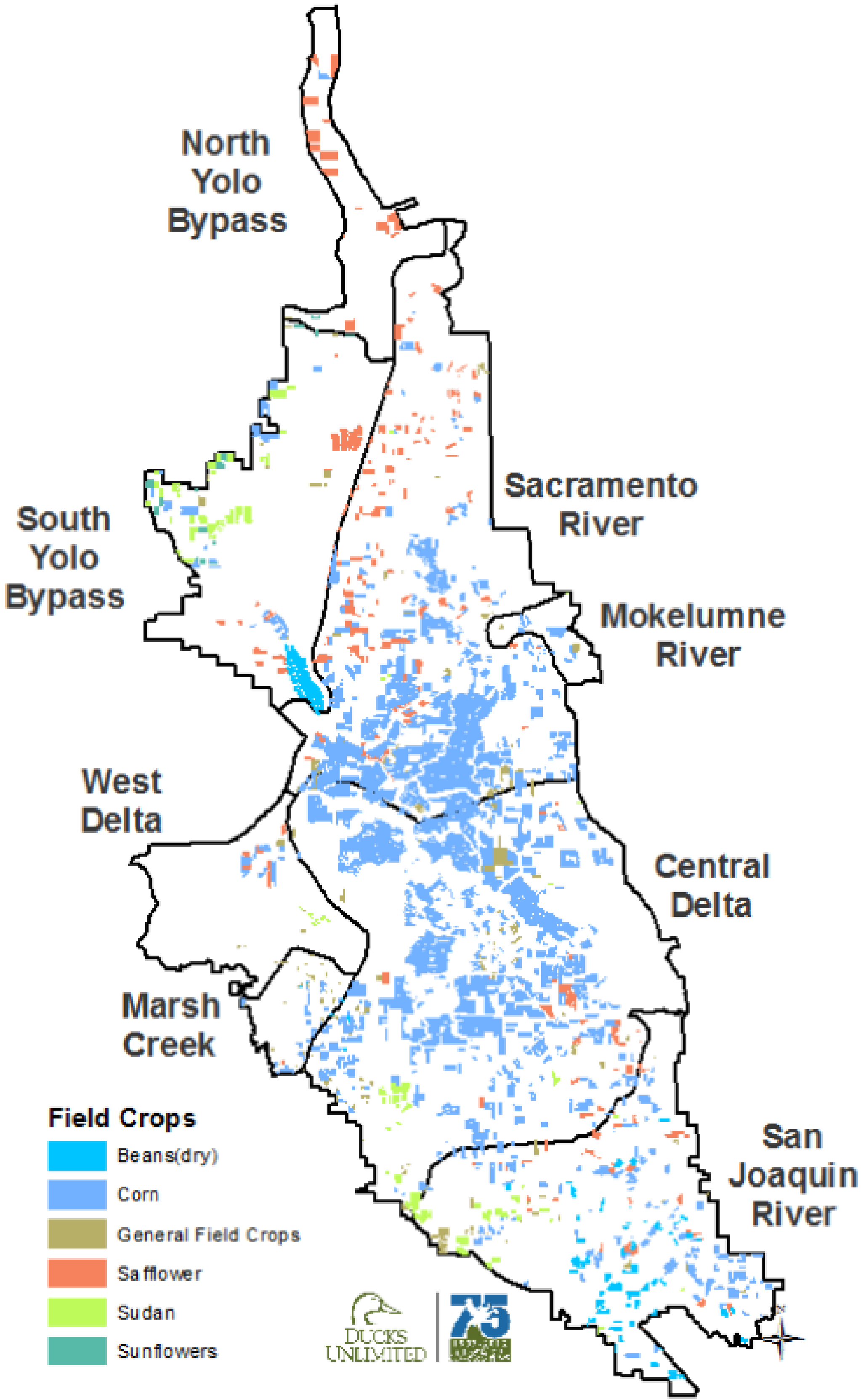


Figure 11. Map of the Distribution of Pasture, Grain, and Hay Land Uses in the Study Area

(From Petrik, 2012)

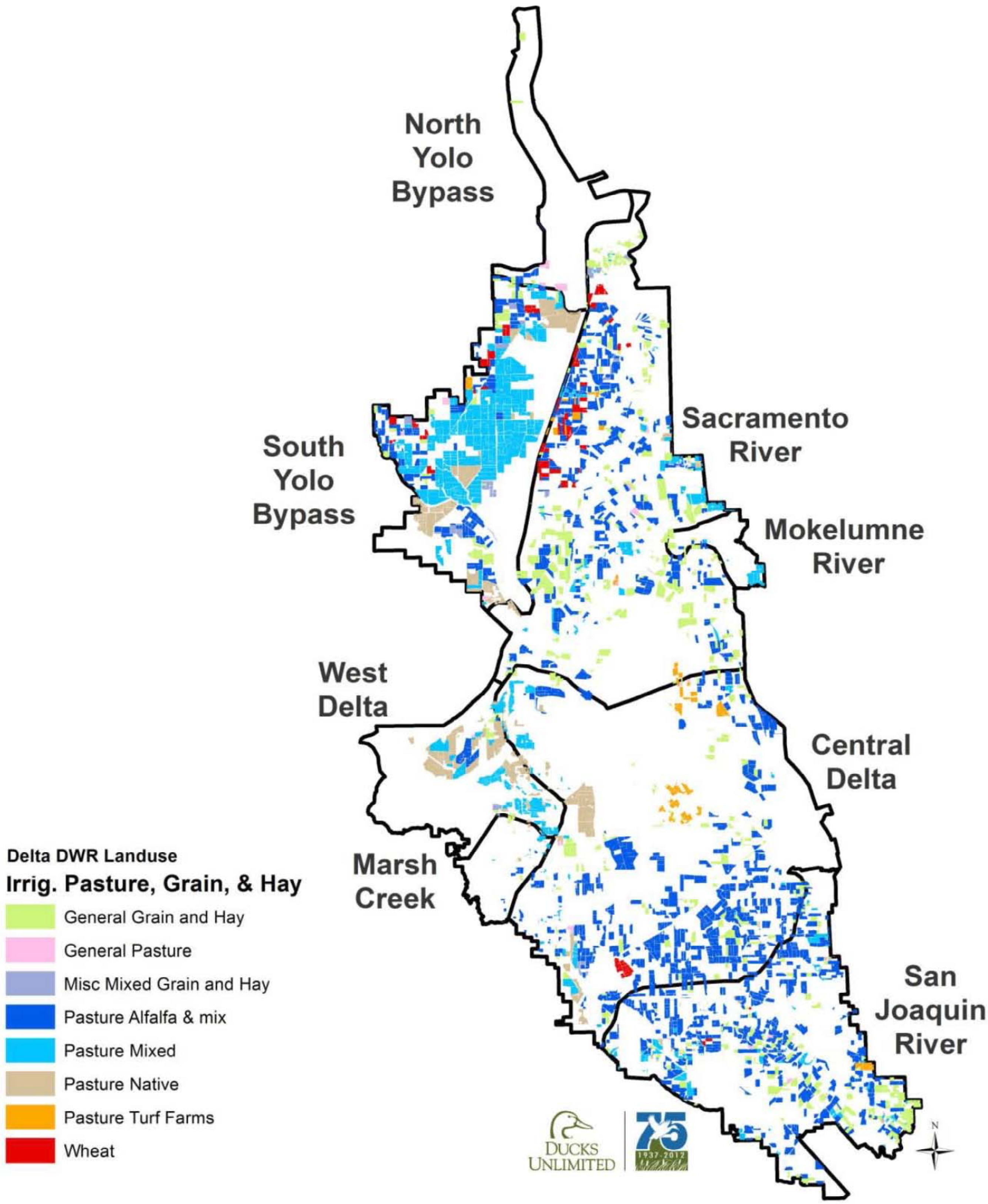
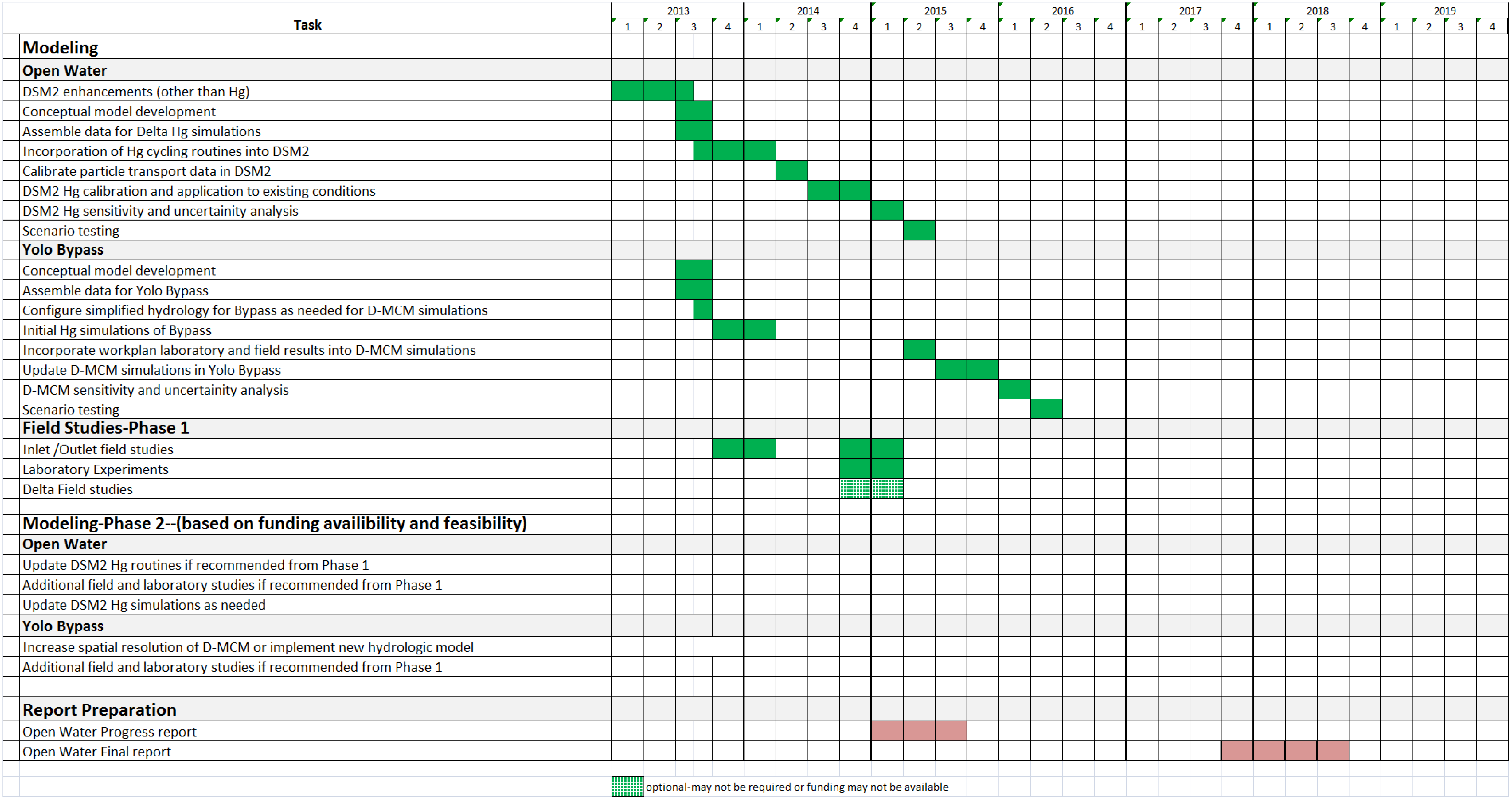


Figure 12. Phase 1 Workplan Schedule



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Appendices to the

METHYLMERCURY CONTROL STUDY WORKPLAN

Prepared by:

The Open Water Workgroup
Department of Water Resources
Central Valley Flood Protection Board
California State Lands Commission
U.S. Army Corps of Engineers
U.S. Bureau of Reclamation

APPENDIX A DWR DELTA SIMULATION MODEL 2 (DSM2) BACKGROUND

What can DSM2 do for you?

Delta Simulation Model 2 (DSM2)

DSM2 represents Delta channels and sloughs bounded by Sacramento in the north, Vernalis in the south, and Martinez in the west, including Suisun Bay and Suisun Marsh.

DSM2 is developed and maintained by the California Dept. of Water Resources (DWR)

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm

DSM2 is publically available without cost, and it is supported by the DSM2 User's Group.

DSM2 is a computer model of water flow, velocity, depth, salinity and water quality in the Sacramento-San Joaquin Delta

- ❑ How is DSM2 used?
  - Historical representation every 15 minutes from 1990-2010
  - Real-time forecasting to support water project operations
  - Explore proposed future projects and operations
- ❑ What are some applications of DSM2?
  - Bay-Delta Conservation Plan
  - Support DWR's Municipal Water Quality Investigations
  - Climate change and sea level rise
  - Fish movement (particle tracking)
  - Flow visualization
- ❑ Who uses DSM2?
  - Federal, state, and local water agencies
  - Consultants and academic researchers
- ❑ How do I know that DSM2 represented the Delta well?
  - DSM2 was calibrated to field observations in an open process involving several agencies
- ❑ What flows and exports are represented in DSM2?
  - Inflows: Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers; tidal flows from San Francisco Bay
  - Exports: State Water Project, Central Valley Project, Contra Costa Water District, North Bay Aqueduct
- ❑ What Delta flow structures are included in DSM2
  - Delta Cross Channel
  - Montezuma Slough Salinity Control Gates
  - Clifton Court Forebay intakes
  - South Delta temporary barriers
  - Yolo Bypass
  - Proposed structures for future alternative studies
- ❑ Does DSM2 have any unique features?
  - Ability to operate structures by user defined rules

A 1.0 INTRODUCTION

The Delta Simulation Model 2 (DSM2) is a one-dimensional mathematical model for dynamic simulation of hydrodynamics, water quality and particle tracking in a network of riverine or estuarine channels. DSM2 can calculate stages, flows, velocities, mass transport processes for conservative and non-conservative constituents including salts, water temperature, dissolved oxygen, nutrients, and trihalomethane formation potential, and transport of individual particles. DSM2 thus provides a powerful simulation package for analysis of complex hydrodynamic, water quality, and ecological conditions in riverine and estuarine systems. DSM2 is a public model and is available for download at http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm. DSM2 has been utilized for studies by several agencies and consulting firms including the California Department of Water Resources, the United States Bureau of Reclamation, Contra Costa Water District, the State Water Resources Control Board, UC Davis, Stanford, CH2MHill, Metropolitan Water District, National Marine Fishery Service, Fish and Wildlife Service, California Department of DFW, ICF International, Resource Management Associates, and Montgomery Watson Harza.

The following document briefly describes DSM2, its major applications and its calibration and validation.

A 2.0 DESCRIPTION OF DSM2

A 2.1 DSM2 Domain

Although DSM2 can be used for any river system, the basic DSM2 grid covers the area shown in Figure A1. The major boundaries are the Sacramento River at I Street in Sacramento, the San Joaquin River at Vernalis and the tidal boundary at Martinez. Figure A2 shows how the model is defined for the delta. Each line segment and each circle are referred to by numbers that DSM2 uses for its calculations. The bathymetry (depth, width, area) of the channels in the Delta is also required for simulations in addition to a description of gates and barriers.

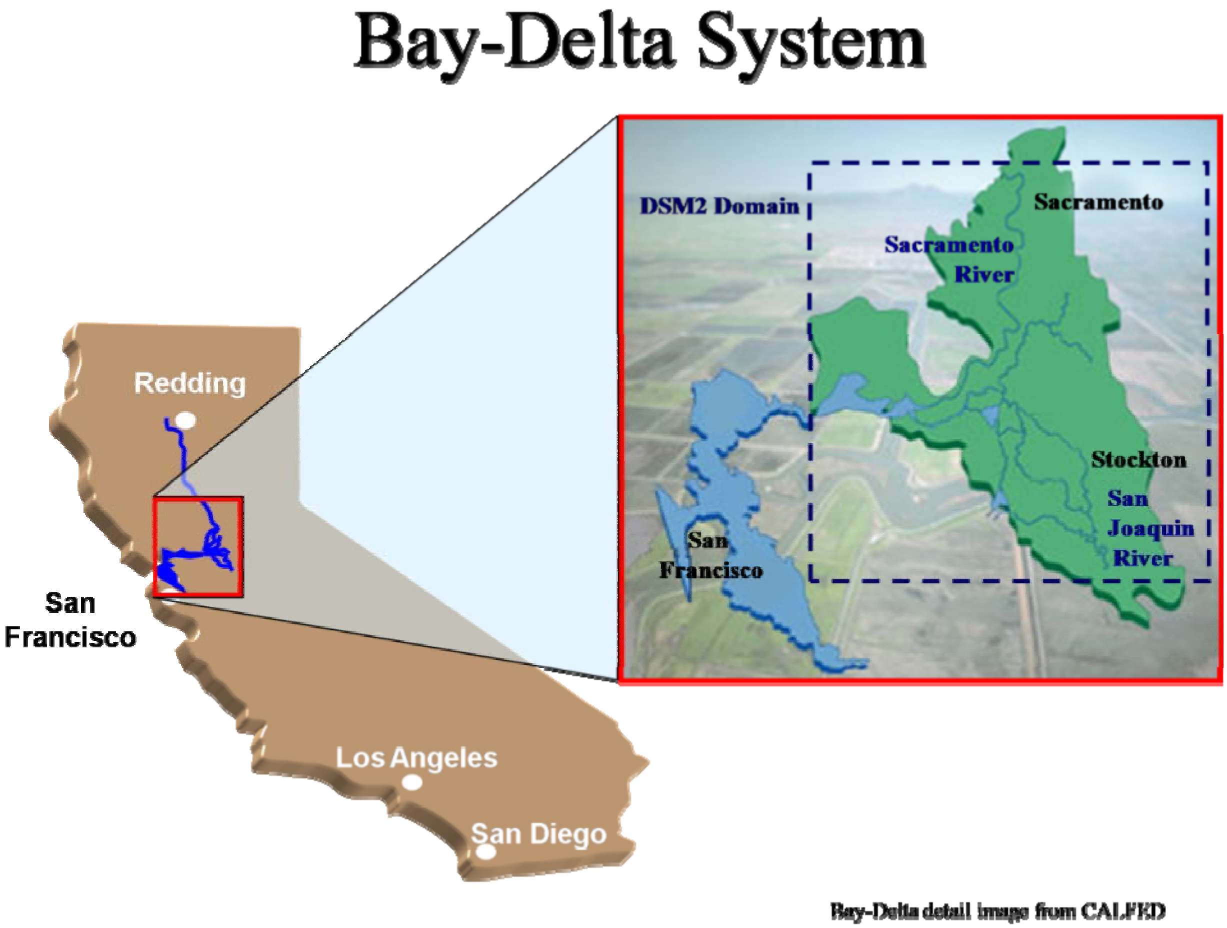

Figure A1 DSM2 Domain

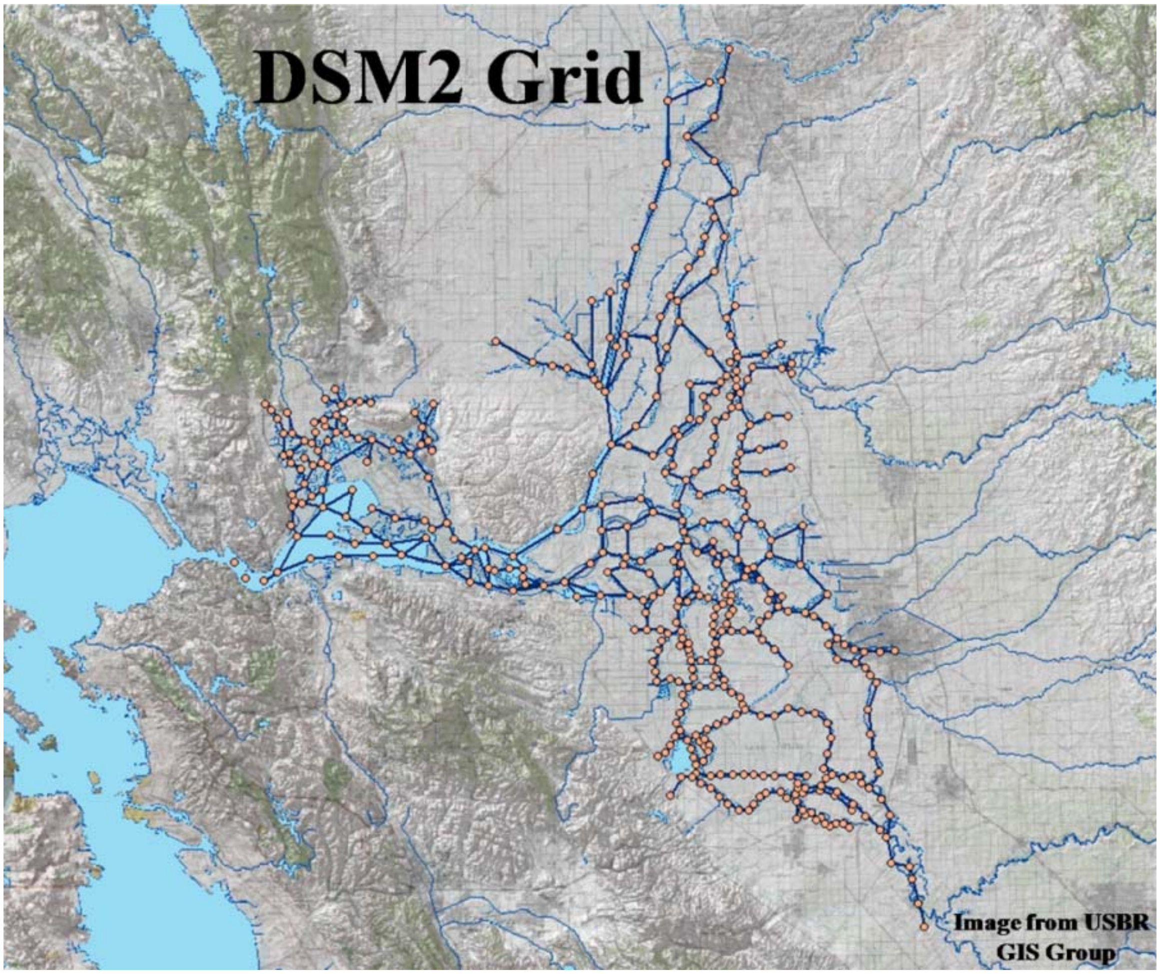

Figure A2 DSM2 Grid

A 2.2 DSM2 Boundary Conditions

In addition to the geometry, DSM2 requires flow and quality boundary conditions in order to simulate the stage, flows, velocities, and quality in the interior Delta. Figure A3 shows the boundary conditions. These boundary conditions include:

- inflows from rivers
- municipal and agricultural returns
- quality of inflows and returns
- exports
- municipal and agricultural diversions
- ocean boundary stage (water level)

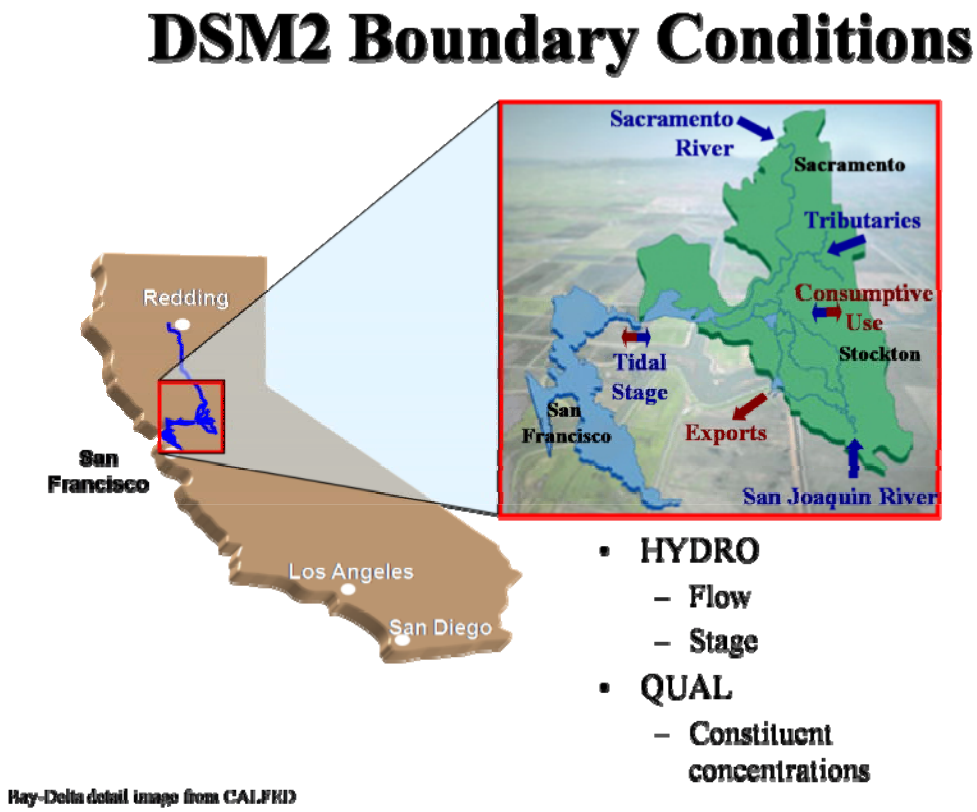

Figure A3 DSM2 Boundary Conditions

A 2.3 DSM2 Modules

DSM2 consists of three modules: HYDRO, QUAL, and PTM. The relationship between HYDRO, QUAL and PTM is shown in Figure A4. HYDRO simulates one-dimensional hydrodynamics including flows, velocities, and water surface elevations. HYDRO provides the flow input for QUAL and PTM. QUAL simulates one-dimensional fate and transport of conservative and non-conservative water quality constituents given a flow field simulated by HYDRO. PTM simulates quasi 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO. PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete organisms such as fish eggs and larvae.

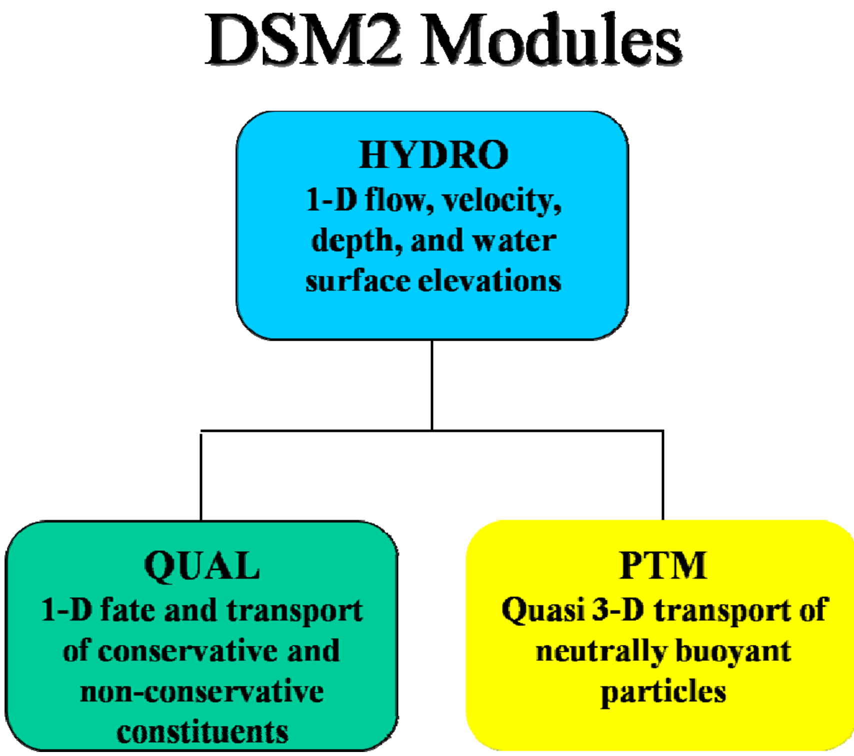

Figure A4 DSM2 Modules

A 2.4 DSM2-HYDRO

DSM2 HYDRO is an unsteady, one dimensional, open channel flow model that uses a four-point-implicit solution scheme. The basic formulation was developed by Lew DeLong (USGS) and developed and adapted to the Delta by DWR staff. The input required by DSM2 HYDRO is:

- Delta bathymetry
- Mannings n (calibration parameter)
- Gate configurations and operations
- Boundary Flows – inflows, exports, diversions and returns
- Boundary Stage (currently at Martinez)
- Initial Conditions
- Time step (usually 15 minutes)
- Output type and locations

A 2.4.1 DSM2-QUAL

DSM2 is a Branched Lagrangian Transport Model. The basic formulation was developed by Harvey Jobson (USGS) and developed and adapted to the Delta by DWR staff. It models dispersion of conservative constituents (e.g., salt) and models the dispersion and kinetics of non-conservative constituents. The input required by DSM2-QUAL is:

- Delta bathymetry
- Dispersion coefficients (calibration parameter)
- Rate coefficients (calibration parameter for non-conservative constituents)
- Gate configurations and operations
- Velocities and flow areas from DSM2-HYDRO output
- Inflow and Ocean Boundary Quality
- Atmospheric inputs if needed for non-conservative constituent modeling
- Boundary stage
- Initial Conditions
- Time step (usually 15 minutes)
- Output type and location

Figure A5 shows the steps and input needed to make a DSM2-HYDRO and a DSM2-QUAL Simulation.

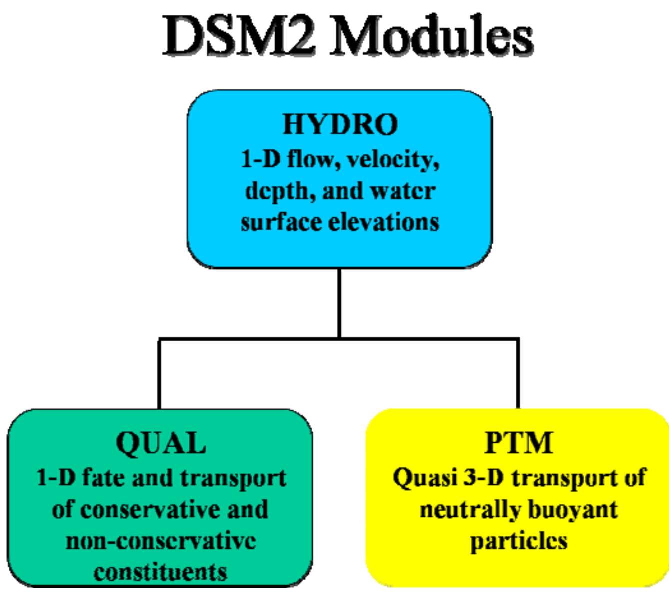

Figure A5 Steps for DSM2 Quality and Hydrodynamics Simulation

A 2.5 DSM2-PTM

DSM2-PTM is a quasi-three dimensional particle tracking model. The three dimensional flow field is determined by fitting velocity profiles to the average DSM2-HYDRO cross sectional velocity. Those velocity profiles combined with mixing model the dispersion of the particles as they move through the channels. The original formulation was developed by Gilbert Bogle. DSM2-PTM was further developed and adapted to the Delta by DWR staff. The input required by DSM2-PTM is:

- Profile and mixing coefficients (calibration parameters)
- Delta bathymetry
- Gate configurations and operations
- Velocities and flow areas from DSM2-HYDRO output
- Particle input locations, number of particles and length of input
- Time step (usually 15 minutes)
- Output type and locations

A 2.6 Gate Operations

DSM2 has a fairly sophisticated treatment of gates within its input files. Gates can be defined with multiple devices at one gate location. That could include several gate sections at different positions or could be a combination of weirs with culverts. The gates can also be controlled through operating rules that can be triggered by hydrodynamic changes such as increases in flows or differences in water levels. Figure A6 shows an example of a gate being opened and closed based on water levels at a specified location.

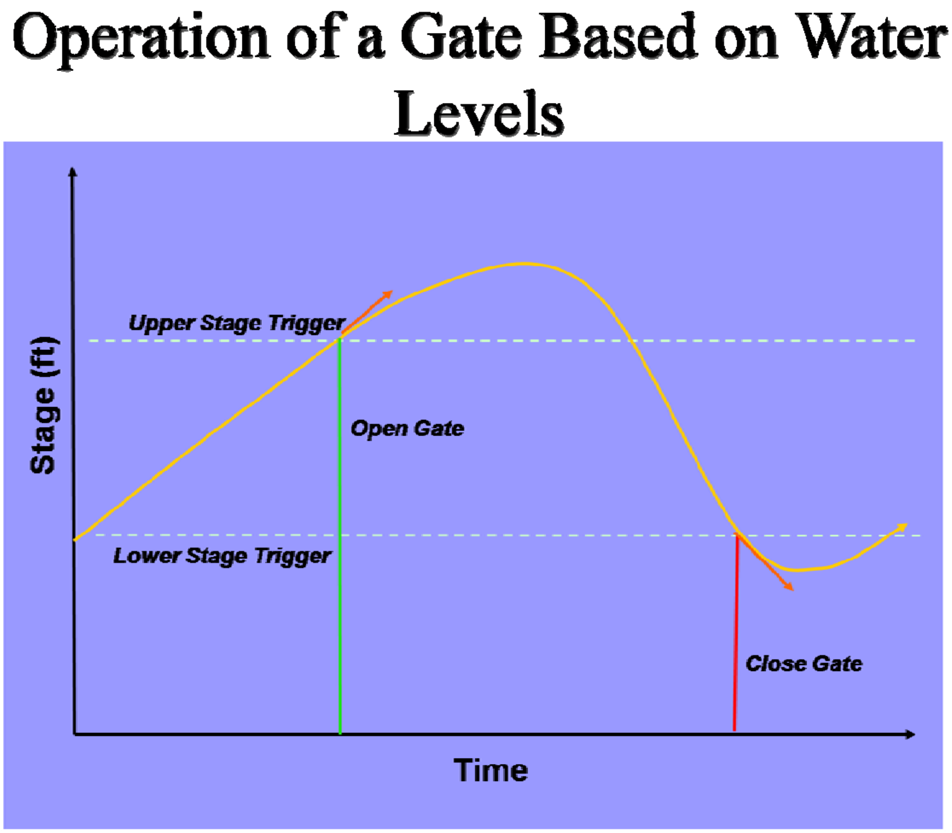

Figure A6 Gate Operation - Water Level Trigger

A 2.7 Delta Island Consumptive Use and Water Quality

One of the most important inputs into DSM2 is the agriculture diversion and return flows and water quality. Since this is not measured in the Delta, other models are used to estimate these values. The Delta Island Consumptive Use (DICU) Model is used to compute monthly average Delta island diversions, seepage and return flows. Input needed for DICU is:

- Land use and Irrigation practices (does not change from year to year)
- Water year type (Sacramento River 40-30-30 Index)
- Atmospheric data (monthly average precipitation and pan evaporation)

The monthly average return water quality values are determined using historical data. The values vary month to month but not year to year.

A 3.0 DSM2 MODES OF APPLICATION

DSM2 is usually used for three kinds of Delta simulations: historic conditions, forecasting future conditions (real-time), and planning studies (Figure A7).

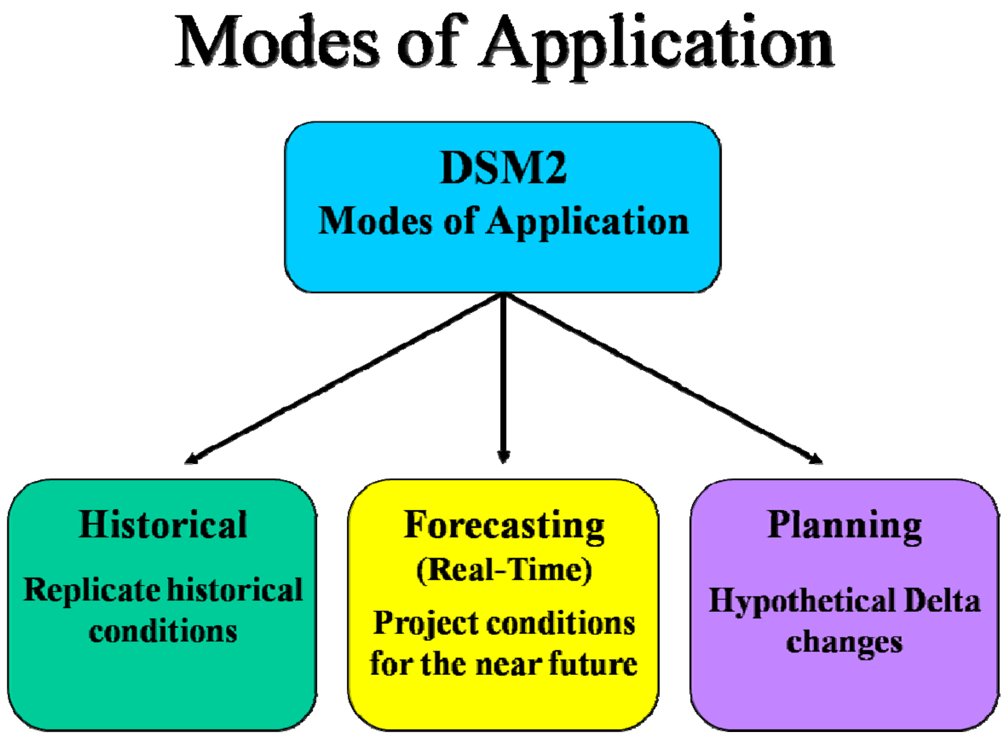

Figure A7 DSM2 Modes of Application

Each type of DSM2 study is briefly described below.

A 3.1 Historical Simulations

Historical simulations replicate past operations, hydrologic conditions, water quality and Delta configurations. These historical simulations enable calibration and validation of the model by comparison of simulation results and field data. Historical simulations also augment available field data to provide a more spatially and temporally complete representation of the hydrodynamic and water quality conditions for that time period.

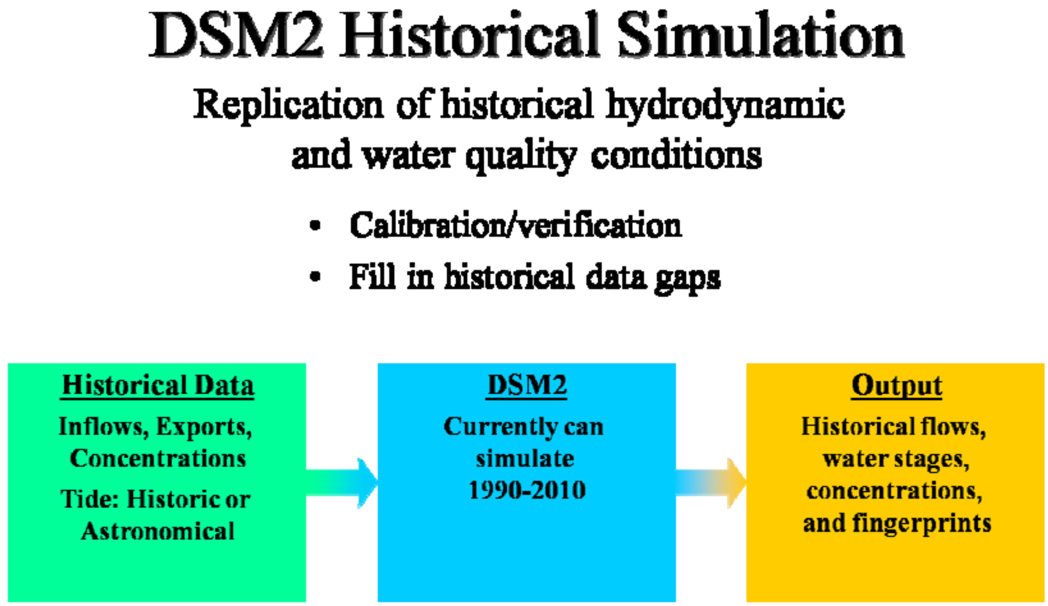

Figure A8 DSM2 Historical Simulation

A 3.2 Forecasting Simulations

Forecasting simulations, also known as real-time simulations, use recent field data and forecast data to project Delta conditions into the near future (typically one to ten weeks). Recently collected historical data provide current conditions for the Delta. Recent tidal elevations at Martinez are used with an astronomical tide forecast to project the Martinez tide into the near future. Corresponding hydrodynamic and water quality conditions in the Delta are then simulated. Forecasting simulations can assist State Water Project operations decisions.

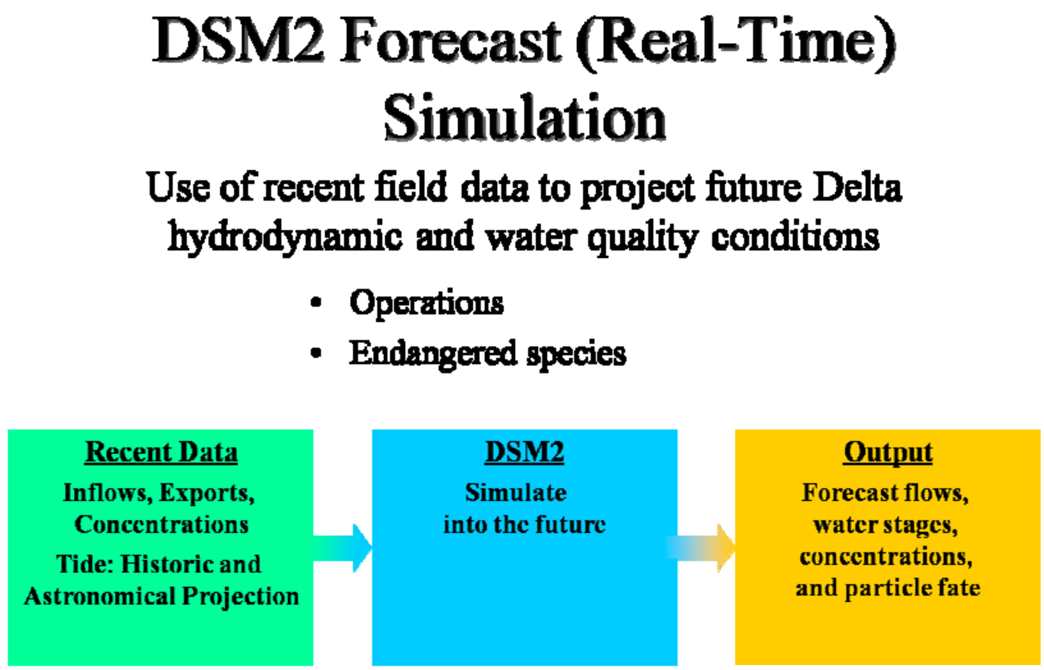

Figure A9 DSM2 Forecast Simulations

A 3.3 Planning Studies

Delta planning studies evaluate how hypothetical changes to factors such as hydrologic regimes, water quality standards, system operations, and Delta configurations may impact Delta conditions. To explore the impacts of a given scenario under various hydrologic conditions, DSM2 planning studies are typically run under a 16-year sequence of Delta inflows and exports derived from statewide water transfer and storage simulations using CALSIM. Planning simulations can use historical or astronomical tidal data which incorporate influences of the spring-neap tidal cycle. Planning simulations typically assess impacts of proposed changes to Delta operations or configuration such as modified reservoir releases or dredging of channels. Planning study may also investigate impacts of hypothesized changes in the natural environment such as sea level rise.

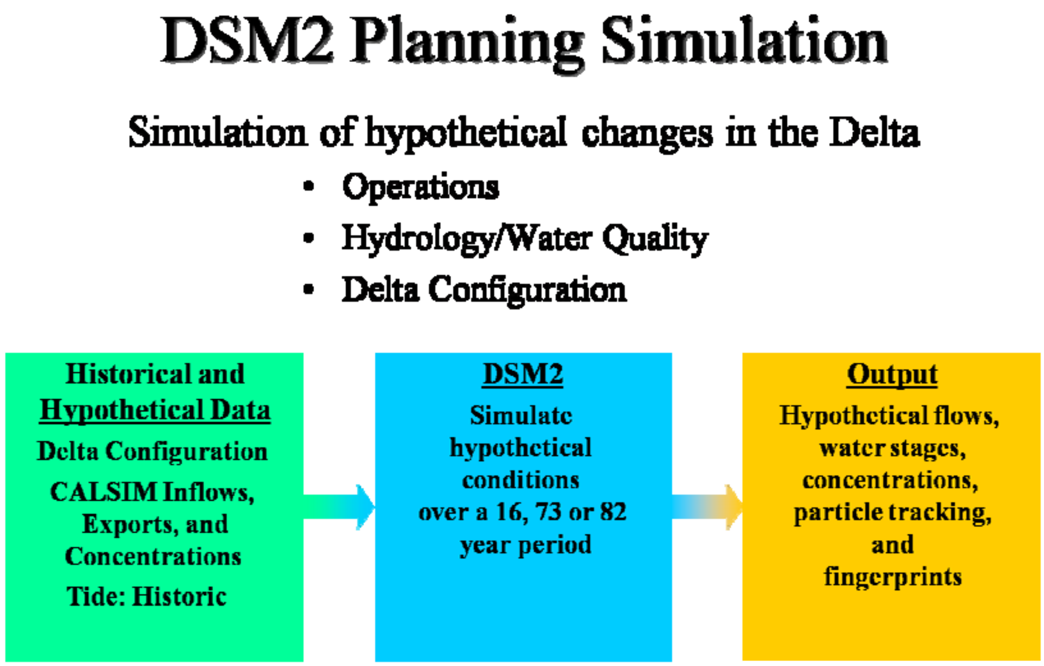

Figure A10 DSM2 Planning Simulations

A 4.0 CALIBRATION AND VALIDATION OF DSM2

A 4.1 Calibration of DSM2 in 2000

DSM2 was calibrated by the Interagency Program Project Work Team in 2000. The web site http://modeling.water.ca.gov/delta/studies/validation2000/map.html has an interactive map that shows the validation of the model during that time period. This map is shown in 0. Figure A12 shows the periods for which DSM2 was calibrated and validated.

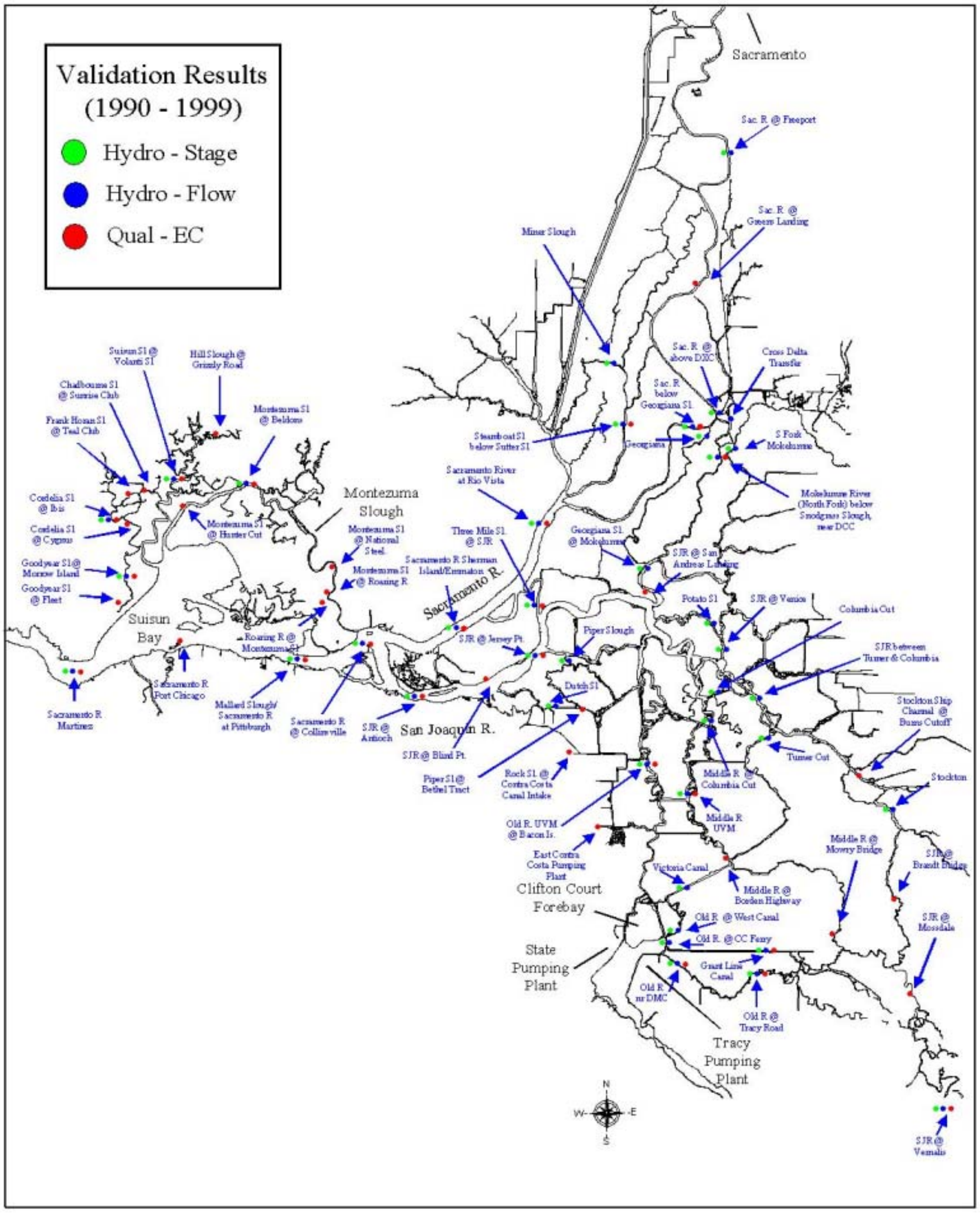

Figure A11 DSM2 2000 Validation Map

Calibration and Validation Periods

HYDRO

- Calibration
  - May 1988
  - April 1997
  - April 1998
  - Sept-Oct 1998
- Validation
  - WY 1991 - 1998

QUAL

- Calibration
  - Oct 1991 - Oct 1994
- Validation
  - WY1991 - 1998

Figure A12 DMS2 Calibration and Validation Periods

A 4.2 Calibration of DSM2 in 2009

In 2009, DSM2 was recalibrated by CH2MHill for work in support of the Bay-Delta Conservation plan. This new calibration utilized bathymetry and flow data collected since 2000 for the calibration. The work was presented in 2009 to the DSM2 Users group for review. The presentation can be found at http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/DSM2UsersGroup/DSM2_Recalibration_102709.pdf. The full calibration report is available upon request. Figure A13 shows the bathymetry that was updated for the new calibration.

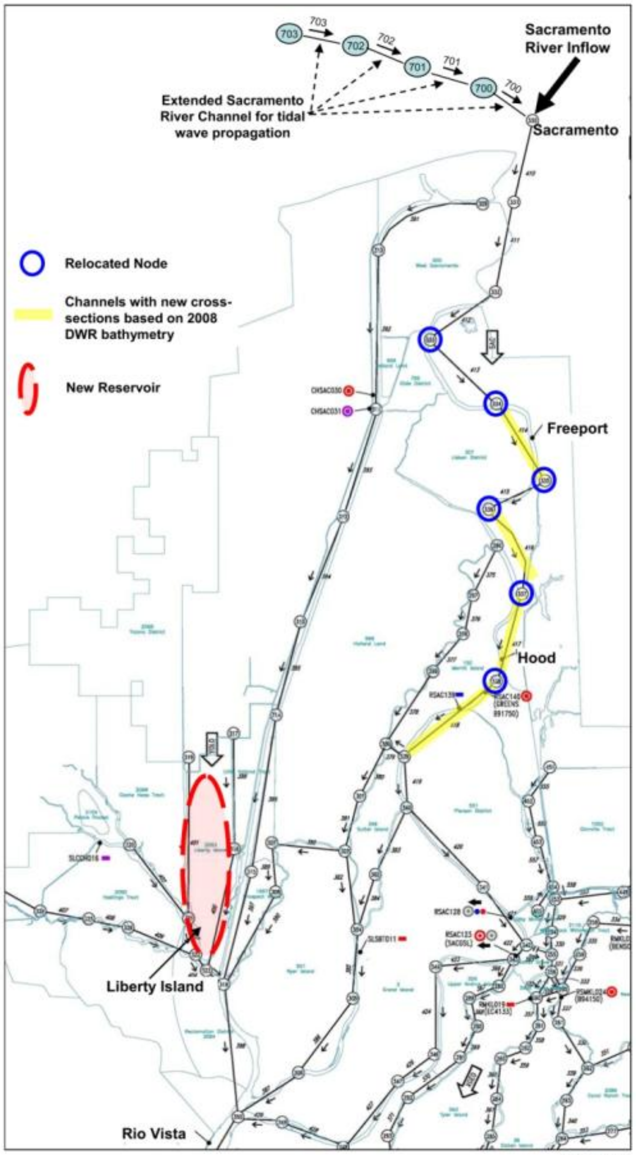

FIGURE 2-2
DSM2 Model Grid in the North Delta Showing the Grid Modifications Performed as Part of the Recalibration Effort

Figure A13 2009 DSM2 Bathymetry Update

Figure A14 and Figure A15 are example flow results for two locations in the Delta, Sacramento River below Georgiana Slough and the Sacramento River above the Delta Cross Channel. Obs is measured field data. Hist_Lib is the DSM2 results with Liberty Island flooding in place.

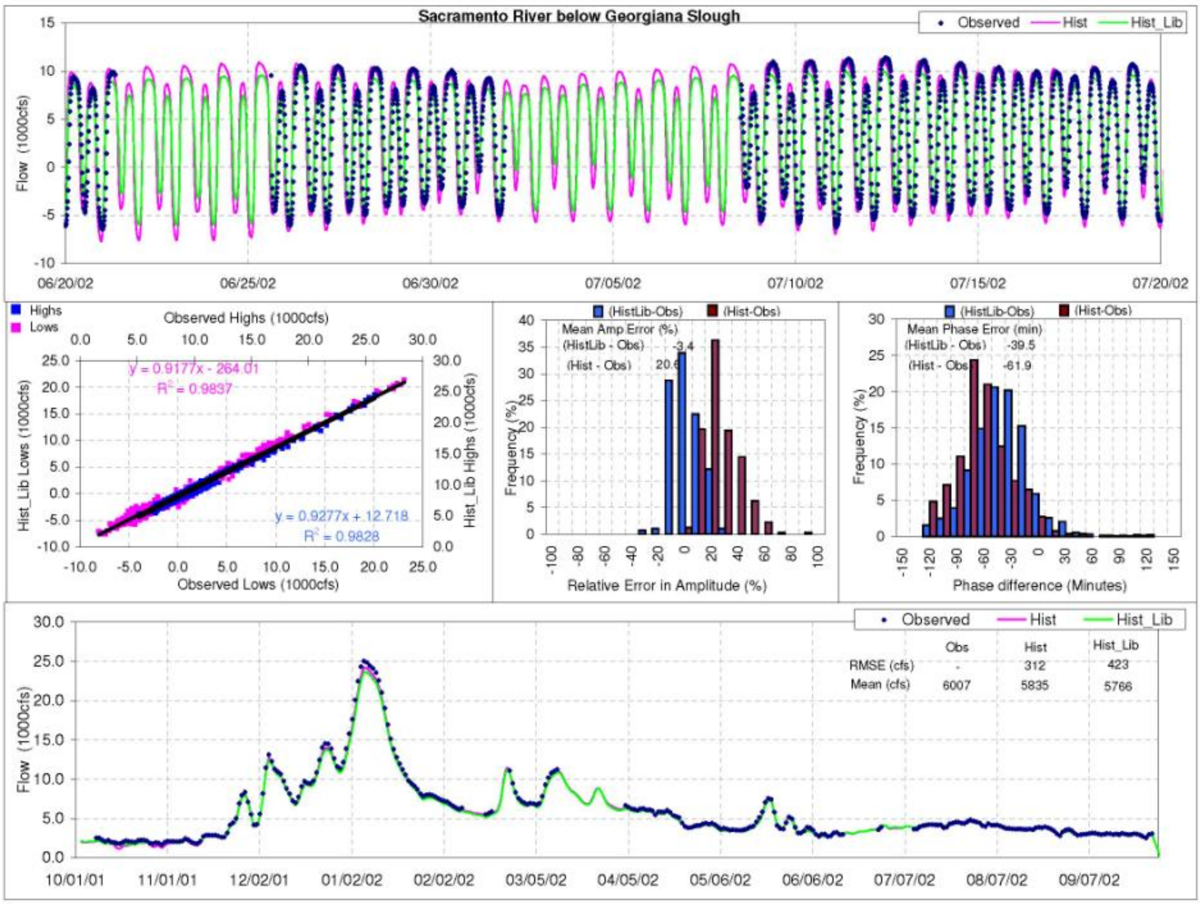

Figure A14 2009 DSM2 Calibration, Sacramento River Below Georgiana Slough

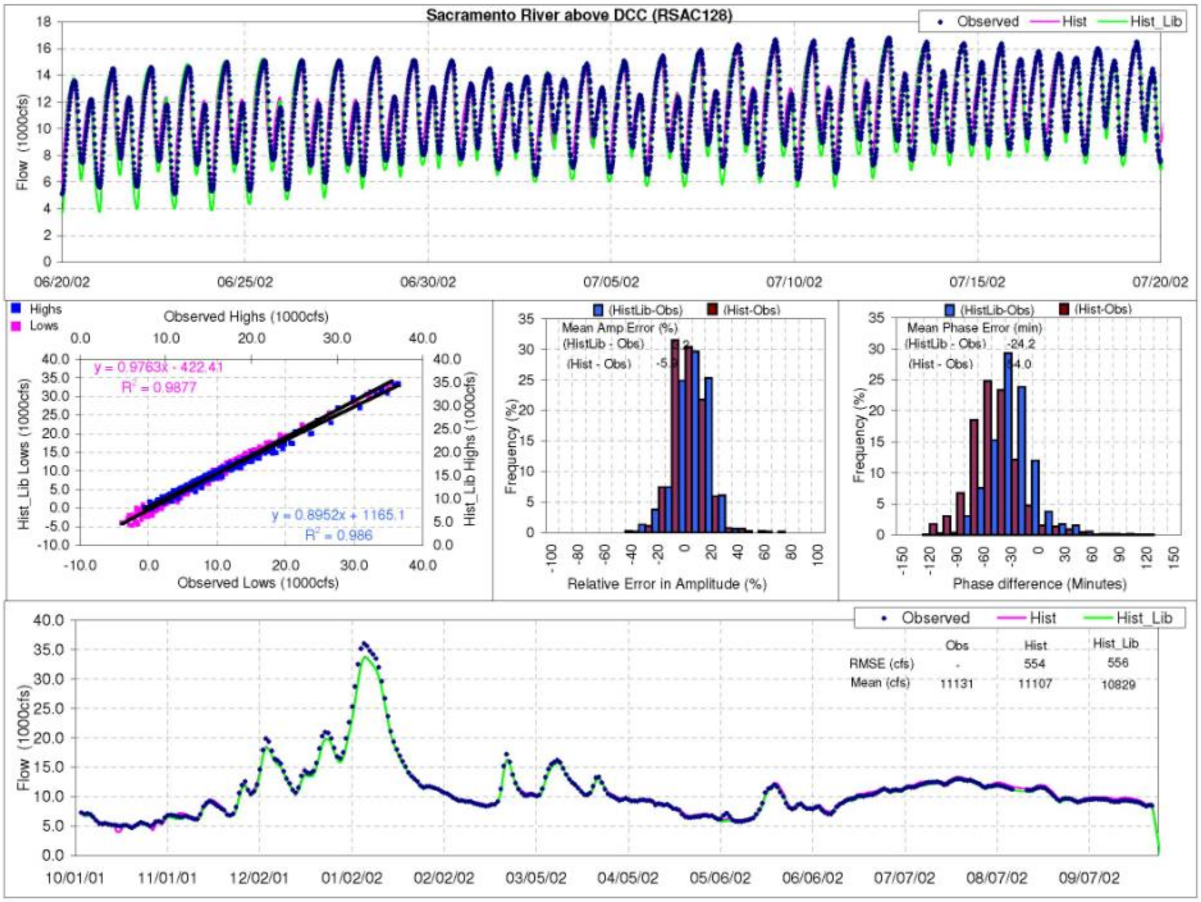

Figure A15 2009 DSM2 Calibration, Sacramento River Above the Delta Cross Channel

A 5.0 ADDITIONAL INFORMATION

Information on DSM2 can be found at http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/index.cfm.

That website will give links to DSM2 executables and source code and also links to documentation including presentations from the DSM2 User Group and Annual Reports to the State Water Resources Control Board.

APPENDIX B DYNAMIC MERCURY CYCLING MODEL (DMCM) BACKGROUND

B 1.0 INTRODUCTION

The Dynamic Mercury Cycling Model (D-MCM) (EPRI, 2009) simulates mercury (Hg) cycling and bioaccumulation in aquatic systems. Three Hg forms are simulated (inorganic Hg(II), methylmercury (MeHg), elemental Hg) in water, sediments and a food web (Figure B1). It can be set up as a single cell or in configurations up to 3D as required (new in Version 4.0), and can simultaneously simulate open waters and wetlands, which can include multiple species of aquatic vegetation (Figure B1). Major processes considered in the D-MCM include inflows and outflows (surface and groundwater), Hg partitioning on solids, particulate settling, decomposition at the sediment/water interface and within sediments, resuspension and burial, atmospheric deposition, air/water gaseous exchange, industrial Hg point sources, in-situ transformations (e.g., biological methylation and demethylation, MeHg photodegradation, Hg(II) reduction and oxidation), mercury kinetics in plankton, and bioenergetics related to MeHg fluxes in fish. Mercury partitioning can include two components: instantaneous equilibrium for some solids-binding sites and slow adsorption/desorption of Hg on other solids sites if desired. This is potentially important in situations such as historical Hg deposits from mining with strongly bound Hg that is effectively unavailable to desorb as a source for methylation. Fluxes associated with macrophytes include root uptake, conversion of inorganic Hg(II) to elemental Hg within the plant, air/leaf exchange of elemental Hg related to transpiration, leaf accumulation of atmospheric deposition, and die-off of macrophytes to sediments. Four types of particles can be included: labile organics, refractory organics, inorganic fines, and coarse fines. Each particle type has unique properties (type and quantity of carbon, density, settling and resuspension velocity, Hg partitioning). The bioavailability of Hg for various reactions is predicted using thermodynamic speciation and assigning individual or groups of complexes as being available for reactions.

The food web can include multiple trophic levels (e.g., plankton, benthos, several fish species) with up to 30 food web compartments. Fish migration is an option if desired. Fish mercury concentrations tend to increase with age, and are therefore followed in each year class of each fish species using bioenergetics equations. D-MCM can be used deterministically or probabilistically, the latter using a Monte-Carlo approach.

D-MCM considers water level fluctuations and wet/dry cycles, however the scientific understanding is incomplete. The model's ability to accurately predict effects of wetting and drying on Hg cycling is therefore in need of additional development and testing. This aspect of D-MCM is currently being improved via the application of the model to a wetland (Marcell Experimental Forest, Minnesota) that experiences water table fluctuations and received experimental additions of sulfate. D-MCM also includes a probabilistic capability to quantify uncertainty in model predictions and identify factors and data gaps introducing the most uncertainty into model predictions.

D-MCM has been used on several large multidisciplinary Hg research studies, including the Gulf of Mexico (Harris and others, in press), Florida Everglades (Harris and others, 2003a), METAALICUS (Harris and others., 2007; Harris and others., in prep.), and Wisconsin Lakes (Hudson and others., 19944). It has also been used in TMDL related studies in Florida (Atkeson et al., 2003), Wisconsin (Harris and others, 2003b), Colorado (Colorado Department of Public Health, 2003), and Arizona (Arizona DEQ and others, 1999). D-MCM was recently used to simulate the effects of climate change on Hg cycling and bioaccumulation in the Great Lakes Basin, funded by the United States Environmental Protection Agency (US EPA) (Harris and others, 2012) and to simulate a broader range of human influences on Hg cycling and bioaccumulation in the Great Lakes, initially modeling Lake Michigan. The study is funded through the Great Lakes Restoration Initiative, via the US EPA. Factors being modeled include wetland restoration, climate change, invasive species and reduced atmospheric Hg deposition.

A new version of D-MCM, Version 4.0 will be used for Phase I modeling. The Electrical Power Research Institute (EPRI)plans to make the new model available in the public domain (as is the case for Version 3), which allows anyone to obtain and use the model.

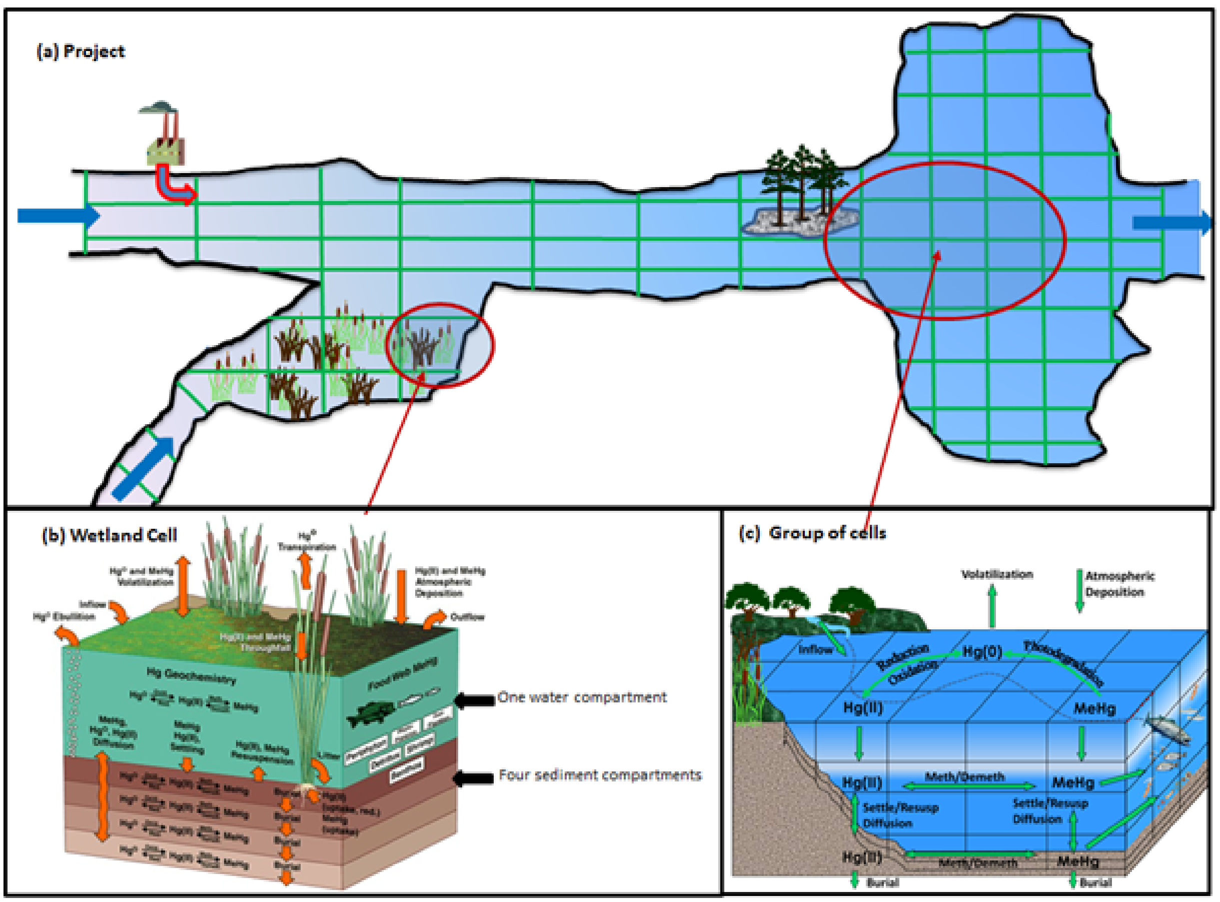

Figure B1 Conceptual Diagram of Hg Cycling in D-MCM

B 2.0 LITERATURE CITED

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Harris, R.C., D. Hutchinson, J.W.M. Rudd, P.J. Blanchfield, C. Gilmour, H. Hintelmann, J.P. Hurley, C.A. Kelly, D.P. Krabbenhoft, M.J. Paterson, C.L. Podemski, K.A. Sandilands, V.L. St. Louis, and M.T. Tate (In Preparation) Application of a Mechanistic Model to Simulate Mercury Cycling and Bioaccumulation in Lake 658, Ontario during the METAALICUS experiment.

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Harris, R.C., J.W.M. Rudd, M. Amyot, C. Babiarz, K.G. Beaty, P.J. Blanchfield, R.A. Bodaly, B.A. Branfireun, C.C. Gilmour, J.A. Graydon, A. Heyes, H. Hintelmann, J.P. Hurley, C.A. Kelly, D.P. Krabbenhoft, S.E. Lindberg, R.P. Mason, M.J. Paterson, C.L. Podemski, A. Robinson, K.A. Sandilands, G.R. Southworth, V.L. St. Louis, and M.T. Tate (2007) Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition. Proceedings of the National Academy of Sciences of the United States of America 104(42): 16586–16591

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APPENDIX C BACKGROUND INFORMATION FOR FIELD SAMPLING

C 1.0 INTRODUCTION

Water quality and mercury (Hg) process data already exist for some sections of the Sacramento San Joaquin Delta (Delta); however, limited process data exists for the Yolo Bypass under different flood conditions. Foe and others (2008) defined two different flooding scenarios in the Yolo Bypass; a) mini-flood events, defined as when flows in Cache and/or Putah Creeks are greater than the carrying capacity of their channels resulting in local flooding, (no spillage over Fremont Weir), and b) flood events, defined as flows in the Sacramento River of approximately 56,000 cubic feet per second (cfs) resulting in overtopping of the Fremont Weir and wide-scale flooding of the Yolo Bypass. The Dynamic Mercury Cycling Model (D-MCM) will require methylmercury (MeHg) process data under both types of flood conditions; therefore, the Open Water Workgroup (Workgroup) intends to focus its field work on collecting field data for this data gap. The extent of the Total Maximum Daily Load (TMDL) for the Yolo Bypass is shown in Figure C1.

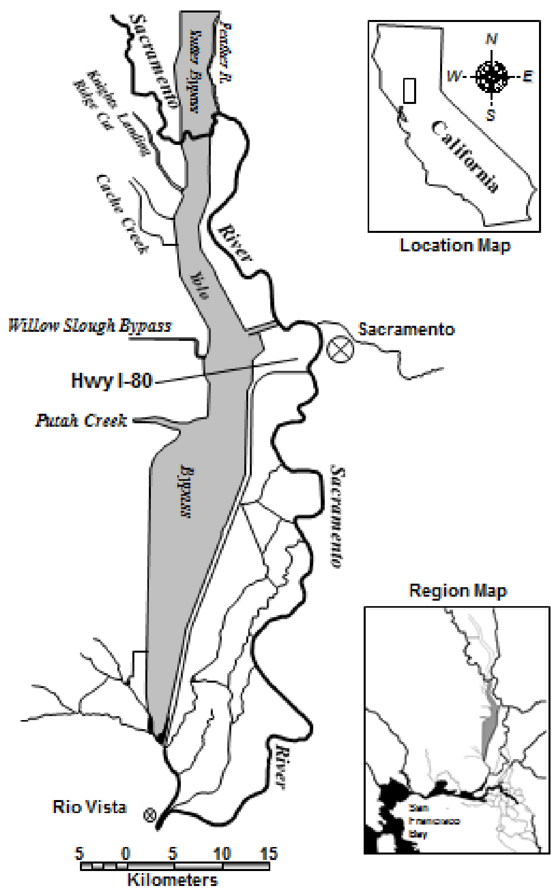

Figure C1 Geographical Location and Reach of the Yolo Bypass. (From Sommer and others, 2007)

One data gap related to MeHg production in the Yolo Bypass is whether different processes drive MeHg production under different types of flooding events in the Yolo Bypass. Available data show that during flood events MeHg production increases positively as a function of flow (Foe and others, 2008). One hypothesis is that due to the short residence time (approximately one to two days) and the large volumes moving through the Yolo Bypass, MeHg production is a reflection of the erosion of particles (Foe and others, 2008). However, little data exists for MeHg processes under mini-flood events with longer residence times, such as the mini-flood events that will increase under the proposed notching of the Fremont Weir. Potentially, with longer residence times, MeHg processes may switch from a flow dominated process to an in-situ sediment flux processes. However, since previous studies in the Yolo Bypass collected only unfiltered MeHg data, we cannot evaluate whether the increase was from dissolved or particulate processes, therefore, by default, only suspended sediment related processes can be examined.

As shown in Figure C2 and Figure C3, most load data were collected when Yolo Bypass outlet flows were greater than 20,000 cfs (Foe and others, 2008). Mini-flood events were only sampled twice. To fully understand the dynamics of MeHg production in the Yolo Bypass, data are needed for MeHg production for flows < 20,000 cfs. This is especially important since the flows projected for the proposed notching of the Fremont Weir are expected to be between 3,000 and 6,000 cfs through the Fremont Weir (DWR and USBR, 2012) or about 6,000 to 12,000 cfs in the lower reaches of the Yolo Bypass (Marianne Kirkland, pers. comm.). Compared to current large flooding events, notching of the Fremont Weir could change residence time of flood waters as well as frequency of mini-flood events. Since the Yolo Bypass MeHg allocation is primarily based on outlet flows greater than 20,000 cfs, examining processes and loads in greater detail under mini-flooding events could provide the Central Valley Regional Water Quality Control Board (CVRWQCB) with a broader understanding of the processes that dominate under different flow conditions. Following the Phase 1 data gathering process, this could lead to the recommendation that the CVRWQCB review MeHg production data at low flow and provide both a low flow and high flow MeHg load allocation.

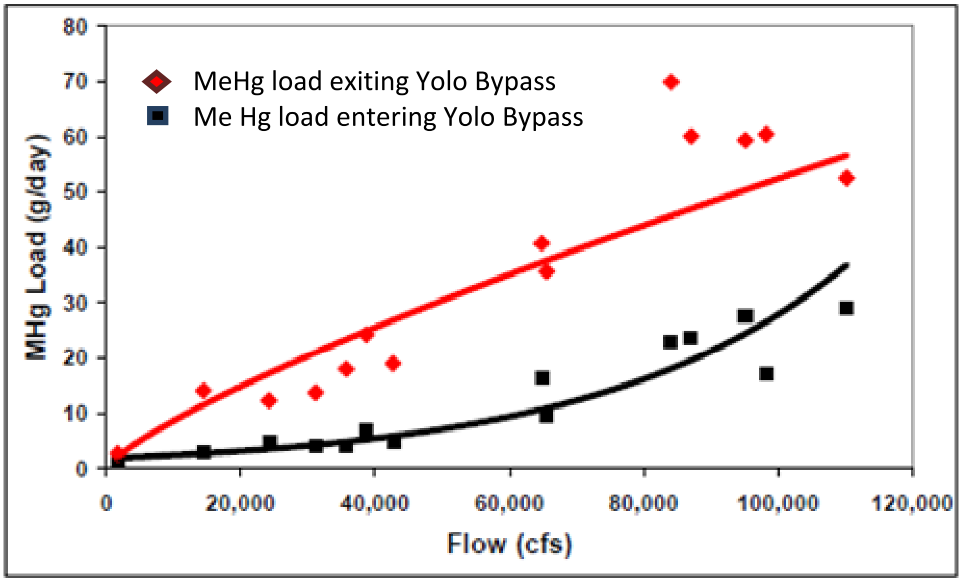

Figure C2 Sum of MeHg Loads Entering and Exiting the Yolo Bypass in g/day

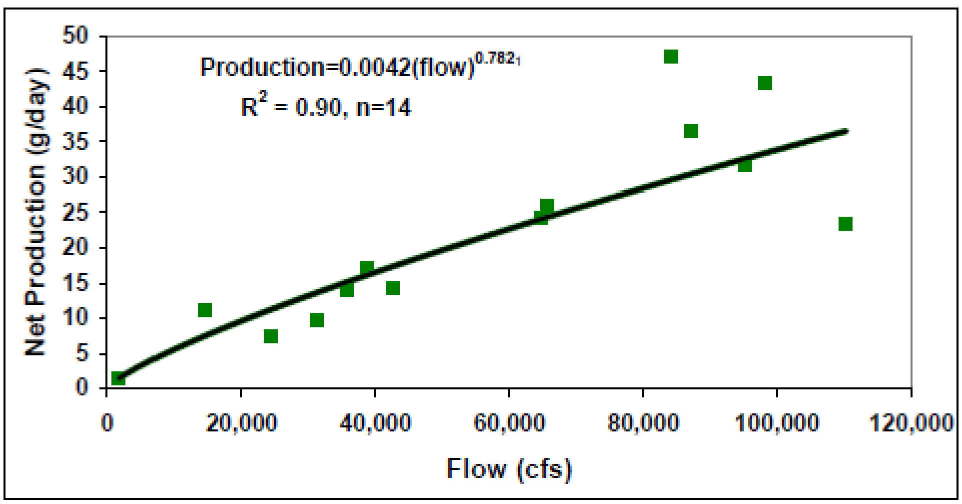

Figure C3 Net Production of MeHg in the Yolo Bypass as a Function of Flow

Additionally, basic MeHg processes required by the Mercury Cycling Model have not been well characterized under different flooding regimes in the Yolo Bypass. Foe and others (2008) collected unfiltered MeHg samples at the inlets and outlets to the Yolo Bypass. Dissolved MeHg concentrations were not analyzed. As shown in Figure C2 and Figure C3 above, loads exiting the Yolo Bypass were greater than loads entering the Yolo Bypass, resulting in a net production of MeHg as a function of flow. At Yolo Bypass flows greater than 20,000 cfs, these results suggest that MeHg is produced as a function of resuspended sediment. However, without the collection of dissolved data under different flow regimes, especially those envisioned under notching of the Fremont Weir, it is difficult to determine if sediment flux processes dominate under lower flow conditions when residence time in the Yolo Bypass increases. If different processes are associated with different flooding regimes, these should be provided to the Mercury Cycling Model.

C 2.0 LITERATURE CITED

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APPENDIX D LETTERS OF SUPPORT

STATE OF CALIFORNIA – THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, GOVERNOR

CENTRAL VALLEY FLOOD PROTECTION BOARD
3310 El Camino Ave., Rm. LL40
SACRAMENTO, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-0653 FAX: (916) 574-0682

April 9, 2008

Mr. Patrick Morris
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Dear Mr. Morris:

Thank you for the opportunity to review the Central Valley Regional Water Quality Control Board's (Water Board) draft Amendments to the Water Quality Control Plan for the Sacramento and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin Delta Estuary. While the Central Valley Flood Protection Board (Board) supports the Water Board's plan to reduce mercury pollution in the Delta, the Board is concerned with the basin plan amendments' proposed actions and requirements with regard to the flood system management in the Yolo Bypass and Cache Creek Settling Basin.

The Board believes that focusing control actions and cleanup of mercury-laden sediment in the Yolo Bypass and Cache Creek Settling Basin before controlling the upstream watershed sources of mercury may be premature. Without source control, mercury-laden sediments will continue to flow into the Bypass and Settling Basin making mercury-reduction efforts endless tasks with no guaranty of success. The Board therefore suggests that the Water Board completes its planned study to identify and evaluate potential mercury reduction projects in the upstream watersheds, particularly the Cache Creek and Putah Creek watersheds, before any characterization and control studies are initiated for the Bypass and Settling Basin. The Board also suggests that any control and cleanup actions be done only after projects to control mercury migration from these upstream sources are identified and implementation assured.

This letter also serves to support the Department of Water Resources comments to the draft basin plan amendment, in particular, to the comments on the flood system management improvement proposals for the Yolo Bypass and the Cache Creek Settling Basin.

The Board would be glad to discuss our comments with you at your convenience. If you have any questions, or wish to arrange a meeting with the Board, please call Mr. Dan S. Fua, Supervising Engineer, at (916) 574-0698.

Sincerely,

Jay S. Punia

Jay Punia,
Executive Officer

cc: Mr. George Qualley, Chief, Division of Flood Management,
Ms. Marianne Kirkland, Division of Environmental Services, DWR

STATE OF CALIFORNIA – THE RESOURCES AGENCY
ARNOLD SCHWARZENEGGER, GOVERNOR

CENTRAL VALLEY FLOOD PROTECTION BOARD
3310 El Camino Ave., Rm. LL40
SACRAMENTO, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-0685 FAX: (916) 574-0682

August 13, 2009

Mr. Patrick Morris
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670

Dear Mr. Morris:

Thank you for the opportunity to review the Central Valley Regional Water Quality Control Board's (Water Board) draft Amendments to the Basin Plan of the Sacramento and San Joaquin River Basins for the Control of Methyl-mercury and Total Mercury in the Sacramento-San Joaquin Delta Estuary. While the Central Valley Flood Protection Board (CVFPB) supports the Water Board's plan to reduce mercury pollution in the Delta, the CVFPB is concerned with the Draft Basin Plan Amendments' proposed actions and requirements with regard to the flood system management in the Yolo Bypass and Cache Creek Settling Basin.

After review of the document, the Board has the following general comments regarding the Cache Creek Settling Basin; please see attached Draft Basin Plan Amendment Comments in the table provided for specific comments to cell content to No. 26, 40, 41, 45, 51-54, and 57:

- The CVFPB feels that our April 9, 2008 comments were not addressed in the Draft Basin Plan Amendments (See attached letter). The CVFPB still feels that downstream dischargers need time to coordinate their efforts with results of upstream studies and implementation measures before possible improvements and mitigation measures are taken downstream of such dischargers.

- The CVFPB feels that after review of the Draft Basin Plan language, and because public safety is the number one priority of the CVFPB, that too much detail was put on assigning numbers to trapping efficiency and timing without enough data to back up the feasibility of such requests in coordination with providing public safety for those who count on the Settling Basin as a flood control feature.

- Coordinated funding options for projects that are for mutual benefit of multiple stakeholders was not discussed and the CVFPB feels that this is a very important issue that needs to be addressed in order to insure that any future improvements are made and that funding will be available and not the sole burden of a single agency.

The Board would be glad to discuss our comments with you at your convenience, or answer any questions you may have. The CVFPB strongly believes in the Water Board's overall mission and effort to reduce mercury and methyl-mercury in the Sacramento-San Joaquin Delta. With any questions or to schedule a meeting with the Board please contact Ms. Nancy C. Moricz, WR Engineer, at (916) 574-2381.

Sincerely,

Dan S. Fua

Dan S. Fua
Supervising Engineer

Cc:

Attachments: CVFPB Basin Plan Amendment comments (provided spreadsheet format)

Letter from Jay Punia, Executive Officer CVFPB to Mr. Patrick Morris at the Water Board – dated April 9, 2008

STATE OF CALIFORNIA – THE NATURAL RESOURCES AGENCY **ARNOLD SCHWARZENEGGER,** GOVERNOR

CA DEPT. OF WATER RESOURCES
1416 Ninth Street, P.O. Box 942836
Sacramento, California 94236-0001
(916) 653-7007 FAX: (916) 653-5028

CENTRAL VALLEY FLOOD PROTECTION BOARD
3310 El Camino Ave., Rm.151
Sacramento, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-0685 FAX: (916) 574-0682

April 7, 2010

Patrick Morris
Senior Water Quality Control Engineer
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Re: Comments on the Proposed Basin Plan Amendment and Delta Methylmercury TMDL

Dear Mr. Morris:

The Department of Water Resources (DWR) and the Central Valley Flood Protection Board (Flood Board) (collectively, "Agencies") submit these joint comments on the proposed Basin Plan Amendment (BPA) and associated February 2010 Staff Report for the Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin Delta Estuary (Delta) (Staff Report). The Agencies appreciate the opportunity to review and comment on these documents which set forth the proposed Delta Mercury Control Program and regulations for implementing a Total Maximum Daily Load (TMDL). The Agencies provide general comments below and specific comments in the attached Table (Attachment 1). The Agencies have also attached a "redline" edit of the proposed BPA (Attachment 2) to reflect possible changes that may address many of our concerns expressed in our comments. Although the Agencies provide suggested changes now, we may have additional comments at the Central Valley Regional Water Quality Control Board (Regional Water Board) hearing on April 22.

DWR and the Flood Board would like to emphasize our support of the Regional Water Board taking necessary steps to identify methods to control methylmercury in the Delta. The newly proposed designated beneficial uses of commercial and sport fishing in the Delta are important uses that need to be addressed in order to protect human health and fish and wildlife. We support certain portions of the Regional Water Board's proposed BPA and TMDL for controlling both methyl and total mercury to reduce fish tissue values to levels that are safe for both fish and wildlife and Delta anglers. For example, the Agencies agree that studies to identify actions to reduce production of methylmercury from dredging, wetland, and aquatic habitat restoration activities should be undertaken. DWR and the Flood Board look forward to working with the Regional Water Board to further refine such actions.

However, the Agencies continue to have significant concerns with certain aspects of the proposed BPA and TMDL. As we have expressed previously during the development of the BPA, the Agencies have concern with Phase 1 improvement actions proposed for the Cache Creek Settling Basin (CCSB). The BPA and TMDL continue to characterize the CCSB as a major source of mercury entering the Delta; however this assertion is incorrect. The Cache Creek watershed is the source of mercury, not the CCSB. The CCSB is a federal Flood Control facility of the Sacramento River Flood Control Project designed with the sole purpose of capturing sediment to minimize downstream flood impacts of sediment on the Yolo Bypass, Sacramento River, the Delta, and the San Francisco Bay. This structure is intended to reduce flooding in the downstream water bodies by minimizing sediment input from the Cache Creek Watershed into those water bodies. The CCSB, by the nature of its sediment capture role, has been and continues to capture mercury entering the basin from the Cache Creek watershed. The BPA and TMDL attempt to reallocate the purpose of the CCSB from single purpose flood control (as designed by the USACE) to multipurpose uses, including increased sediment and mercury capture, above and beyond the design of the flood control feature. Such a change was not envisioned in the federal authorization for the CCSB, and this BPA/TMDL change may not be in the federal interest. We describe these concerns and propose revisions to the BPA in specific comments in Attachments 1 and 2.

In addition, DWR and the Flood Board have fundamental policy, legal, and technical concerns with the joint assignment to our agencies, along with the State Lands Commission (SLC), of the open water allocation as a method to reduce mercury in the Delta. The proposed BPA states that "[o]pen water allocations apply to the methylmercury load that fluxes to the water column from sediments in open-water habitats within channels and floodplains in the Delta and Yolo Bypass." (BPA at 10.) The Agencies believe that it is unreasonable and inappropriate to include the open water allocation as described in the BPA, or to place the burden to meet such an allocation solely on three State agencies. The major source of this methylmercury loading is the mercury-laden sediment underneath the waters that was deposited many years ago from natural and human activities unconnected to activities of these State agencies. We instead recommend that the Regional Water Board recognize this as a Statewide problem that should be remedied through a characterization and control program and not through the use of a TMDL targeted at these three agencies.

We do not believe it is appropriate to characterize DWR, the Flood Board and SLC, collectively, as the "State of California" when assigning the open water allocations. In providing the rationale for assigning the open water allocations to the Agencies, the Regional Water Board staff stated that placing a more upfront and immediate burden on the State government was "in keeping with stakeholder requests" and referenced an April 9, 2008 comment letter signed by various parties ("Comment Letter," attached as Attachment 3). (See also Draft BPA Staff Report at 61, footnote 26.) The major position put forward in the Comment Letter is that substantial mercury load reductions and study requirements should be allocated to the State of California. The letter states that the primary source of methylmercury loading is the sediment underneath the State's waters and, because the People of California own the waters, the State should be held accountable for reducing these loads. (See Comment Letter at 1.)

The Regional Water Board staff responded to this position by assigning the open water allocations to the three state agencies, with the apparent belief that the State's responsibility would be appropriately fulfilled by those agencies. DWR and the Flood Board do not dispute that some of our activities, such as dredging or wetland and aquatic habitat restoration, may affect methylmercury production in the open-water. However, we strongly oppose being solely responsible for meeting the open water allocations simply because we are State agencies.

Importantly, DWR and the Flood Board do agree with the rationale in the Comment Letter for the State responsibility due to mercury contamination as an unfortunate legacy for our State. Mercury is abundant in naturally occurring minerals and rocks of the California Coast Range and Sierra Nevada, which will continue to erode and be deposited in the State's water bodies through natural processes, atmospheric deposition, as well as from anthropogenic activities (primarily historic mercury mining concentrated in the Coast Range, and gold recovery concentrated in the Sierra Nevada foothills and eastern valley). To address this legacy issue, which affects the citizens of California as a whole, the Agencies believe a comprehensive mercury characterization and control program identified with appropriate legislative authority to fund and staff a statewide effort is required. Until such a comprehensive, legislatively authorized and funded approach is developed, the Agencies do not support portions of the proposed BPA that hold them responsible for reducing methlymercury that is not caused by our activities. The Agencies have attached an edited BPA with comments and proposed changes reflecting this position.

The Agencies also believe that the proposed BPA open water allocations narrowly assign responsibility to only State agencies, and that when using the underlying logic of the BPA, federal agencies also should be assigned responsibility. The proposed BPA describes the types of activities that will be subject to the open water methylmercury allocations, including "water management and storage in and upstream of the Delta and Yolo Bypass, maintenance of and changes to salinity objectives, dredging and dredge materials disposal and reuse, and management of flood conveyance flows." (See BPA at 10.) The BPA then identifies the agencies that are responsible for the various activities, including DWR, SLC, the Flood Board, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers and the State Water Resources Control Board (State Water Board). However, despite recognizing that there are numerous other agencies responsible for the types of activities affecting open-water methylmercury production and transport, the proposed BPA assigns responsibility to meet the allocations to only the three State agencies. We believe this is arbitrary and unreasonable.

Another reason to modify the open water allocation is that it assigns the responsibility to meet the allocations before any real analysis has been performed to assess whether the Agencies can feasibly and reasonably reduce methylmercury production in the open water. We believe it is highly unlikely that Agencies will be able to accomplish the methylmercury reductions in a manner envisioned in the BPA.

To properly develop the BPA, the Regional Water Board staff must: 1) conduct an analysis as to whether the fish tissue objective set forth in the BPA can reasonably be achieved; 2) analyze the reasonably foreseeable environmental impacts from the methods of compliance, the reasonably foreseeable mitigation measures, and the reasonably foreseeable alternative means of compliance; and 3) design a program that includes actions that can be reasonably and feasibly implemented. (See Public Resources Code Section 21159(a) and Water Code Section 13241.) The Regional Water Board staff analysis, however, is not adequate to meet this requirement. The Regional Water Board staff identified a few methods of compliance with the open water allocations but these methods focused only on the reduction of total mercury inputs from upstream sources in order to decrease sediment mercury concentrations in the open channels. (See Staff Report at 110, 115-117.) The analysis is unclear as to the Agencies effect on upstream sources of mercury and does not sufficiently analyze whether the

Agencies can feasibly or reasonably reduce methlymercury levels in the open-waters. We believe that one of the main purposes for the Phase 1 studies is to determine the feasibility of control actions that can reduce mercury loading and methylmercury production. As such, DWR and the Flood Board believe assigning responsibility to specific entities for the open water allocations is premature when there is little evidence in the analysis showing feasible or reasonable actions to achieve such allocations.

The last, and extremely important issue the Agencies have with the open water allocations is that it improperly includes flood control and "water management" as activities that are subject to the open water methylmercury allocations. The Agencies interpret the term "water management" to mean activities related to the movement of flows through confined, established Delta conveyance tributaries and channels. Such flow is subject to, and largely the result of, precipitation, snow melt, and other natural processes. Movement of water through the fluvial system will occur regardless of flood control and water management activities and DWR and the Flood Board do not believe that the mere movement of water through established channels should be included in an open water allocation, or any other allocation. The Agencies understand that water management activities may affect the distribution and potentially the resident time of mercury and methylmercury. However, we do not agree that affecting the distribution of methylmercury should be, or legally can be, considered a loading factor.

The "water management activities" described in the BPA cannot be considered point sources or nonpoint sources because they do not add any pollutant to navigable waters, and therefore cannot be regulated in the manner proposed in the BPA. The Regional Water Board staff seem to acknowledge this on page 50 of the Staff Report, which states, in pertinent part: "There are several challenges in developing equitable and effective methylmercury allocations…TMDL regulations and guidance focus on controlling discharges of pollutants to address water quality impairments, and do not clearly address how to handle other contributing factors such as water management activities." In other words, the Regional Water Board staff recognized that water management activities do not discharge mercury or methylmercury into the State's water bodies, which is what a TMDL is designed and intended to address. Therefore, the open water allocations set forth in the BPA pertaining to activities that only affect flow in the Delta channels should not be addressed through a TMDL.

Instead, activities that affect the flow in Delta channels that consistently have water should be considered non-load related contributing factors. Water management activities that affect the distribution of methlymercury or its resident time should not be assigned an allocation, but instead should be viewed as something that potentially contributes to conditions that allow methylmercury to enter into the food chain. Thus, the Agencies believe that the Regional Water Board should take into account the conditions of flow in the watershed when determining the appropriate allocations, but it should not include activities that affect flow into those allocations.

In sum, the Agencies do not believe that there is enough information available for the Regional Water Board to reasonably adopt the open water allocations and the action for the CCSB in the proposed BPA and implementation plan. Currently, it is unclear who is, and who should be, held responsible for the methylmercury loading in the Delta open-water. Also, it is unclear how the existing water quality and flow requirements, and the operations necessary to meet those requirements, will be balanced with the new methylmercury allocations and future control actions.

DWR and the Flood Board believe the most viable solution to fully address the State's responsibility for controlling mercury not related to point and non-point source regulation, and which is not appropriate in a TMDL, is to develop a program, perhaps through legislation, that will create, fund, and staff a statewide mercury characterization and control program. Such a program could be housed within the California Environmental Protection Agency (Cal EPA) and would investigate mercury sources, and identify and implement feasible control actions of sources not appropriate for a TMDL. The program could coordinate with federal, State (including the Delta Stewardship Council), and local public health agencies and local groups to best implement public health advisories and education programs with mercury affected communities. Such an approach would be more appropriate than the proposed TMDL approach because it could identify the funding and develop an implementation plan for addressing mercury contamination in the Delta, while minimizing impacts to existing federal, State, and local public resource programs.

For the above reasons, the Agencies requests that the Regional Water Board not adopt the open water allocations, or at least not assign responsibility, until the Phase 1 studies are completed. The Agencies will continue to work with the Regional Water Board and its staff to develop alternative approaches to addressing methylmercury open water allocation in the BPA. In addition, before adopting the proposed BPA, the Agencies request that the Regional Water Board consider changes to the BPA as identified in our specific comments and revisions identified in Attachments 1 and 2.

If you have any questions regarding the Agencies' comments and suggested changes to the BPA, please contact Dale Hoffman-Floerke, DWR Deputy Director, or your staff may contact Jay Punia, Flood Board Executive Officer, at (916) 574-0609.

Sincerely,

Dale K. Hoffman-Floerke
Deputy Director
Department of Water Resources

Jay S. Punia
Executive Officer
Central Valley Flood Protection Board

Attachments

cc: See attached List

cc: Mr. Charles Hoppin, Chair
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Ms. Francis Spivy-Weber, Vice Chair
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Mr. Arthur Baggett, Board Member
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Ms. Tam Doduc, Board Member
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Mr. Walt Pettit, Board Member
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Mr. Terry Erlewine, General Manager
State Water Contractors
1121 L Street, Suite 1050
Sacramento, California 95814-3944

Ms. Katherine Hart, Chair
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Ms. Cheryl Maki, Vice Chair
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Ms. Pamela Creedon, Executive Officer
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Mr. Dan Odenweller, Board Member
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Ms. Sandra Meraz , Board Member
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Ms. Nicole Bell, Board Member
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Mr. Julian C. Isham, Board Member
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Mr. Karl E. Longley, Board Member
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

Mr. Robert G. Walters, Board Member
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, California 95670

California Regional Water Quality Control Board
Central Valley Region
Katherine Hart, Chair

Matthew Rodriquez
Secretary for
Environmental Protection

11020 Sun Center Drive, #200, Rancho Cordova, California 95670-6114
(916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Edmund G. Brown Jr.
Governor

30 November 2011

Mark Cowin, Director
Department of Water Resources
1416 9th Street
Sacramento, CA 95814

SUBJECT: Delta Mercury Control Program Requirements

The Department of Water Resources, Central Valley Flood Protection Board, and the State Land Commission (Agencies) are receiving this letter because the Delta Mercury Control Program (Delta methylmercury total maximum daily load or TMDL) has identified that water and land management activities under your jurisdiction cause or contribute to elevated levels of mercury and/or methylmercury to the Sacramento-San Joaquin River Delta or Yolo Bypass. This letter summarizes activities and schedules required by the Delta Mercury Control Program for the state Agencies. The first report required to be submitted by each Agency to the Central Valley Water Board is due 20 April 2012, as described later in this letter.

Background

On 22 April 2010, the Central Valley Water Board adopted amendments to the Sacramento River and San Joaquin River Basin Plan (Basin Plan) to establish the Delta Mercury Control Program to address mercury and methylmercury impairments in the Delta. The Delta Mercury Control Program includes fish-tissue objectives for the Delta and methylmercury allocations for NPDES facilities, municipal storm water, agricultural lands, wetlands, and open water in the Delta and Yolo Bypass.

The Delta Mercury Control Program lays out an implementation strategy for the control of methylmercury and total mercury in the Delta and Yolo Bypass designed to reduce methylmercury levels in Delta fish tissue. The Delta Mercury Control Program uses an adaptive management approach that contains two phases. Phase 1, which will last through approximately 2020, is primarily a study period when methylmercury control measures will be developed and evaluated (methylmercury control study(s) (Control Study)). At the end of Phase 1, the Central Valley Water Board will review the study results and will consider revising the fish tissue objectives and methylmercury allocations.

Phase 2, which begins after the Central Valley Water Board conducts its reevaluation of the fish-tissue objectives and waste load and load allocations, will require implementation of the methylmercury controls identified by the Phase 1 studies.

Delta Mercury Control Program Requirements

Your agency is required to comply with the applicable Delta Mercury Control Program requirements contained in the Basin Plan. The following is a summary of requirements for methylmercury control study(s) (Control Study) and specific requirements for discharges from areas managed by your agency. The entire Delta Mercury Control Program can be found at http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/2011oct20/bpa_20oct2011_final.pdf.

The Delta Mercury Control Program includes numeric methylmercury load and waste load allocations. The allocations for wetlands and open water are contained in Table A of the Delta Mercury Control Program. The allocations can be used to inform the type and magnitude of methylmercury management practices that should be evaluated in the Control Studies.

On 20 October 2011, the USEPA approved the Basin Plan amendments, thus establishing the 'effective date' of the Delta Mercury Control Program and the start of the schedule for requirements. A summary table of the Phase 1 Control Study due dates is included.

Phase 1 Methylmercury Control Study Requirements

1. Conduct Control Studies to evaluate existing methylmercury control methods and, as needed, develop additional control methods that could be implemented to achieve your methylmercury load and/or waste load allocations. The Control Studies may be conducted either individually or in conjunction with other entities conducting methylmercury studies. At a minimum, we recommend the State Agencies develop and implement coordinated Control Studies.

2. By 20 April 2012, each Agency must submit a letter to the Executive Officer describing either: (a) how your agency plans to organize with other dischargers and stakeholders to develop and implement a coordinated, comprehensive Control Study Workplan and studies or (b) your agency will develop and implement individual Control Study Workplans and studies.

Workplans

3. Implement the Control Studies through the development and completion of Control Study Workplan(s) that are approved by the Regional Board Executive Officer.

4. By 20 July 2012, submit a Control Study Workplan report containing detailed plans for the Control Studies and Phase 1 activities. The Executive Officer can extend the due date to 20 April 2013 if your organization demonstrates that it is part of a collaborative study.

5. The Control Study Workplan(s) shall provide detailed descriptions of how methylmercury control methods will be identified, developed, and monitored, and how effectiveness, costs, potential environmental effects, and overall feasibility will be evaluated for the control methods.

6. The Control Study Workplan(s) shall include details for organizing, planning, developing, prioritizing, and implementing the Control Studies. Attachment A to this letter contains

general guidelines, expectations and minimum requirements in order for the Control Study Workplans to be considered approvable by the Executive Officer.

7. The Control Studies shall evaluate the feasibility of reducing sources more than the minimum amount needed to achieve allocations.

8. Initiate the Control Studies after Executive Offer approval of the studies. The deadline for initiation of studies is on or before 20 November 2012 for individual studies or 20 August 2013 for coordinated studies.

Reports

9. By 20 October 2015, submit a Progress Report to include Control Study progress to-date and, as necessary, amended Workplans for any additional studies needed to address methylmercury reductions.

10. By 20 October 2018, submit the Control Study Final Report.

11. The Control Study Final reports shall include: a description of methylmercury and/or inorganic (total) mercury management practices identified by the studies; an evaluation of the effectiveness, and costs, potential environmental effects of the management practices; and a discussion of the overall feasibility of the control actions. In addition, final report(s) shall propose points of compliance for non-point sources.

12. In the Final report, your organization shall propose methylmercury and/or inorganic (total) mercury management implementation plans and schedules to comply with methylmercury allocations as soon as possible, but no later than 2030.

13. If the Control Study results indicate that achieving a given methylmercury allocation is infeasible, then your organization shall provide detailed information in the Final Report on why full compliance is not achievable, what methylmercury load reduction is achievable, and an implementation plan and schedule to achieve partial compliance towards meeting the allocation.

Summary of Activities and Reporting Schedule:

Due Date	Activity
20 April 2012	Submit Organizational Report
20 July 2012 20 April 2013 (extended date if granted by Executive Officer for collaborative studies)	Submit Control Study Workplan
Before 20 November 2012, or Before 20 August 2013 (extended date)	Initiate Control Study
20 October 2015	Submit Control Study Progress Report
20 October 2018	Submit Control Study Final Report

A group of stakeholders is involved in planning collaborative methylmercury studies for non-point sources (managed wetlands and irrigated agriculture) in the Delta and Yolo Bypass. If you are interested in coordinating with this group, please contact Stephen McCord, McCord Environmental, Inc. (530) 220-3165 or sam@mccenv.com.

Phase 1 General Requirements (all dischargers)
The following requirements apply to surface water discharges from lands or water under your jurisdiction:

1. Implement reasonable, feasible controls for inorganic mercury.

2. Implement methylmercury management practices identified during Phase 1 that are reasonable and feasible.

Phase 1 Agency Requirements

1. Conduct the Control Studies described in this document and evaluate options to reduce methylmercury in open waters under jurisdiction of the Agencies and in floodplain areas inundated by flood flows.

2. Evaluate your agency's (or combined Agencies') water and land management activities to determine whether operational changes or other practices or strategies could be implemented to reduce ambient methylmercury concentrations in Delta open water areas and floodplain areas inundated by managed floodplain flows. The evaluations shall include inorganic mercury reduction projects.

3. Conduct Control Studies for activities that have the potential to increase methylmercury levels, including water management and impoundment in the Delta and Yolo Bypass, maintenance of and changes to salinity objectives, dredging and dredge materials disposal and reuse, and management of flood conveyance flows.

4. In subareas of the Delta needing reductions in methylmercury, proponents of new wetland and wetland restoration projects scheduled for construction after 20 October 2011 shall (a) participate in Control Studies or implement site-specific study plans that evaluate practices to minimize methylmercury discharges and (b) implement methylmercury controls as feasible.

5. By 20 April 2012, demonstrate how the Agencies have secured adequate resources to fund the Control Studies.

6. The Agencies should coordinate with wetland and agricultural landowners during Phase 1 to characterize existing methylmercury discharges to open waters from lands immersed by managed flood flows and develop methylmercury control measures.

7. Monitoring and Reporting: As part of the Control Studies, nonpoint sources of must develop either individual or coordinated monitoring and reporting plans and determine points of compliance for methylmercury allocations. The Agencies should participate with the Irrigated Lands Coalitions, other wetland managers, and other entities representing nonpoint sources to develop the monitoring and reporting plans.

Dredging and Dredge Material Reuse Requirements
In general, for projects that involve dredging activities and activities in the Delta that reuse dredge material, the Department of Water Resources should minimize increases in methyl and total mercury discharges to Delta waterways.

The following requirements apply to Department of Water Resources' dredging and excavating projects in the Delta and Yolo Bypass where a Clean Water Act 401 Water Quality Certification or other waste discharge requirements are required:

1. Employ management practices during and after dredging activities to minimize sediment releases into the water column.

2. Ensure that under normal operational circumstances, including during wet weather, dredged and excavated material reused at upland sites, including the tops and dry-side of levees, is protected from erosion into open waters.

In addition to the above requirements, the following requirements apply to Department of Water Resources and other State and federal agencies conducting dredging and excavating projects in the Delta and Yolo Bypass:

3. Characterize the total mercury mass and concentration of material removed from Delta waterways by dredging activities.

4. Conduct monitoring and studies to evaluate management practices to minimize methylmercury discharges from dredge return flows and dredge material reuse sites.

5. By 20 October 2013, submit a study workplan(s) to evaluate methylmercury and mercury discharges from dredging and dredge material reuse, and to develop and evaluate management practices to minimize increases in methyl and total mercury discharges. The proponents may submit a comprehensive study workplan rather than conduct studies for individual projects. The comprehensive workplan may include exemptions for small projects. Upon Executive Officer approval, the plan shall be implemented. Studies should be designed to achieve the following aims for all dredging and dredge material reuse projects. When dredge material disposal sites are utilized to settle out solids and return waters are discharged into the adjacent surface water, methylmercury concentrations in return flows should be equal to or less than concentrations in the receiving water. When dredge material is reused at aquatic locations, such as wetland and riparian habitat restoration sites, the reuse should not add mercury-enriched sediment to the site or result in a net increase of methylmercury discharges from the reuse site.

6. By 20 October 2018, submit final reports to include the results and descriptions of mercury and methylmercury control management practices.

The U.S. Army Corps of Engineers has been studying methylmercury during dredging projects in the Delta for several years. Regional Board staff is willing to work with the Department of Water Resources to evaluate further study needs.

Exposure Reduction Program
The Delta Mercury Control Program requires the development and implementation of an exposure reduction program (ERP) to protect those people who eat Delta fish by reducing their methylmercury exposure and its potential health risks.

The first step is for staff to work with multiple stakeholders to develop an Exposure Reduction Strategy. The Strategy will determine how dischargers will be responsible for participating in an ERP, set performance measures, and propose a collaborative process for developing, funding and implementing the program. Staff will be submitting the Exposure Reduction Strategy to the Executive Officer by 20 October 2012. Staff may be contacting your organization for input on the strategy.

By 20 October 2013, your agency, individually or collectively with other stakeholders, is required to submit an exposure reduction workplan and implement the workplan six months after Executive Officer approval. The Board is working towards sponsoring a researcher/facilitator to assist with the Strategy and workplan requirements.

Your compliance with the Delta Mercury Control Program requirements and timely submittal of reports is sincerely appreciated. However, we must advise that failure or refusal to comply with the above Basin Plan requirements for the Delta Mercury Control Program will result in the Executive Officer issuing Orders for a technical report per Section 13267 of the California Water Code.

If you have any questions regarding this letter, please contact Janis Cooke, jcooke@waterboards.ca.gov, (916) 464-4672, or Patrick Morris, pmorris@waterboards.ca.gov, (916) 464-4621.

Kenneth D. Landau
Assistant Executive Officer

Attachment A: Guidance for Organizational Letters and Control Study Workplans

cc: Gail Kuenster, DWR Environmental Services
Michael Perrone, DWR Environmental Services

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY EDMUND G. BROWN JR., GOVERNOR

CENTRAL VALLEY FLOOD PROTECTION BOARD
3310 El Camino Ave., Rm. 151
SACRAMENTO, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-2380 FAX: (916) 574-0682

April 10, 2012

Ms. Pamela Creedon
Executive Officer
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, Suite 200
Rancho Cordova, California 95670-6114

Subject: Central Valley Flood Protection Board Request for Time Extension and Intent to Participate and Partner with Other Agencies in Phase 1 Methylmercury Control Studies

Ms. Creedon:

This letter is in response to the California Regional Water Quality Control Board, Central Valley Region's letter dated November 30, 2011 to the Central Valley Flood Protection Board (CVFPB), notifying CVFPB of its need to comply with applicable Delta Mercury Control Program requirements contained in the Sacramento-San Joaquin River Basin Plan (Basin Plan). As described in the November 30, 2011 letter, CVFPB must conduct Control Studies and evaluate options to reduce methylmercury in the following areas under the CVFPB's jurisdiction:

Delta open water areas and floodplain areas inundated by managed floodplain flows.

Each entity required by the Basin Plan to participate in Phase 1 Methylmercury Control Studies is required to submit a letter to the Executive Officer of the Regional Board describing how it plans to organize with other entities to develop a coordinated, comprehensive Control Study Workplan, or develop individual Control Study Workplans. CVFPB will partner with other agencies and non-governmental entities for the study category listed above. CVFPB, in partnership with the Department of Water Resources (DWR), will conduct studies as described in the Dredging and Dredge Material Reuse section of the Basin Plan amendment. With respect to the Cache Creek Settling Basin, CVFPB, in partnership with DWR, will conduct studies as described in the Cache Creek Settling Basin Improvement Plan and Schedule. This letter summarizes partnership information.

Open Water Workgroup – CVFPB participation and partners

CVFPB has open water responsibilities and participates in wetland restoration on floodplains periodically inundated with managed flood flows. CVFPB will partner in the Open Water Workgroup as described below.

1. **Unique name of coordinated group:** CVFPB is participating in the Methylmercury TMDL Open Water Workgroup (Open Water Workgroup).

2. **Contact Information:** The Open Water Workgroup is comprised of the Department of Water Resources, the Central Valley Flood Protection Board (CVFPB), the State Lands Commission (SLC), the US Army Corp of Engineers (USACE), and the US Bureau of Reclamation (USBR). Contact information for workgroup members is as follows:

    a. **DWR**—Chris Wilkinson; cdw@water.ca.gov; 916-376-9704
    b. **CVFPB**—Len Marino; lmarino@water.ca.gov; 916-574-0608
    c. **SLC**—Cy Oggins; cy.oggins@slc.ca.gov; 916-574-1880
    d. **USACE**—Cory Koger; Cory.S.Koger@usace.army.mil; 916-557-5112
    e. **USBR**—Michael Mosley; mmosley@usbr.gov; 916-978-5119

3. **Central Valley Flood Protection Board's Role:** CVFPB is a Cooperating Entity in the Open Water Workgroup. In this role, we will participate in Workgroup meetings and review draft deliverables.

    CVFPB will be involved in control study coordination, including development of site specific workplans. Depending on control study requirements, CVFPB may contribute control study sites and/or facilities, fund data collection and analysis, and help prepare reports.

4. **Statement of Commitment:** CVFPB commits to participating in the Open Water Workgroup as a Cooperating Entity as described above.

5. **Request for Time Extension:** The Basin Plan requires that Control Study Workplans be submitted to the Central Valley Water Board by July 20, 2012. The Executive Officer may allow an additional nine months for Workplans being developed by a coordinated approach. With an extension, the due date for coordinated Control Study Workplans is April 20, 2013.

    We hereby request the nine-month extension, which is justified by the time needed to address the control study's inherent complexity in terms of the scientific understanding, diversity of land and water management measures, and coordination required between cooperating agencies and within CVFPB.

6. **Schedule for Milestones for Coordination Activities:** These key milestones will be accomplished by the collaborative Open Water Workgroup to meet the April 20, 2013, deadline:

    - Identify potential mercury control practices to be evaluated. [due July 2012]
    - Produce a control study workplan for site-specific application. [due April 2013]

In summary, CVFPB appreciates the opportunity to participate in the Phase 1 control studies and expects results that provide feasible management practices that benefit and enhance CVFPB's mission.

Please contact me at (916) 574-0609 if you have any questions regarding these comments. Questions regarding CVFPB's participation in and coordination of Phase 1 Mercury Control Studies should be directed to the Mr. Len Marino at (916) 574-0608 or via email at lmarino@water.ca.gov.

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Sincerely,

Jay S. Punia

Jay Punia, P.E.
Executive Officer

cc: (Please see attached list)

cc: Ms. Kathy Kelly, Chief
Bay-Delta Office
Department of Water Resources
1416 9th Street, Room 215-37
Sacramento, California 95814

Ms. Gail Newton, Chief
Floodsafe Environmental Stewardship and Statewide Resources Office
Department of Water Resources
901 P Street, Room 411-A
Sacramento, California 95814

Ms. Mary Simmerer, Sustainability Coordinator
Delta & Statewide Water Management Office
Department of Water Resources
1416 9th Street, Room 1115-16
Sacramento, California 95814

Ms. Michelle H. Denning, Chief
Mid-Pacific Region Division of Planning
Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825

Mr. Michael Mosley
Mid-Pacific Region Division of Planning
Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825

Colonel William J. Leady, District Engineer
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814

Mr. Cory Koger
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814

Mr. Cy R. Oggins, Chief
Division of Environmental Planning and Management
California State Lands Commission
100 Howe Ave., Suite 100-South
Sacramento, California 95825

Mr. Mark List, Chief
Flood Maintenance Office
Maintenance Support Branch
Division of Flood Management
Department of Water Resources
3310 El Camino Ave., Room 146
Sacramento, California 95821

Mr. Len Marino, Chief Engineer
Ms. Nancy Moricz, Staff Engineer
Central Valley Flood Protection Board

Chris Wilkinson, DES
Carol DiGiorgio, DES
Petra Lee, DES
(via email)

Moricz, Nancy@DWR

From: Wilkinson, Christopher@DWR
Sent: Friday, August 17, 2012 12:17 PM
To: Cooke, Janis@Waterboards
Cc: DiGiorgio, Carol@DWR; Martin, Christopher@DWR; Cory Koger; Cy Oggins; Cyndi Herzog; Frances Brewster; Gius, Frederick@DWR; Clark, Julianna@DWR; Kirk Nelson; Kerckhoff, Laurence@DWR; Marino, Len@DWR; Linda Standlee; lsmith@mwdh2o.com; Michael Mosley; phutton@mwdh2o.com; Lee, Petra@DWR; Stefanie.Morris@bbklaw.com; terlewine@swc.org; tmongan@gmail.com; Moricz, Nancy@DWR; gary.gill@pnnl.gov; mstephenson@mlml.calstate.edu
Subject: Open Water MeHg Concept Proposal Aug 17, 2012
Attachments: Open Water Workgroup Concept Proposal_08-17-12.docx

Janis,

On behalf of the Methylmercury TMDL Open Water Workgroup, I am attaching the "Open Water Workgroup Methylmercury Control Study Workplan Concept Proposal" for review by the Delta Mercury Technical Advisory Committee. The concept proposal is a result of a coordinated effort by the members of the Open Water Workgroup and our partners. If you have any questions about the content of the proposal, I request that you please address them to the entire group.

We look forward to the response of the TAC and to meeting with the TAC, currently scheduled for September 19, to discuss their comments.

Thank you,
Chris Wilkinson

Chris Wilkinson, Chief
Ecological Studies Branch
Department of Water Resources
Division of Environmental Services
(916) 376-9704
cdw@water.ca.gov

Moricz, Nancy@DWR

From: Wilkinson, Christopher@DWR
Sent: Friday, August 17, 2012 12:17 PM
To: Cooke, Janis@Waterboards
Cc: DiGiorgio, Carol@DWR; Martin, Christopher@DWR; Cory Koger; Cy Oggins; Cyndi Herzog; Frances Brewster; Gius, Frederick@DWR; Clark, Julianna@DWR; Kirk Nelson; Kerckhoff, Laurence@DWR; Marino, Len@DWR; Linda Standlee; lsmith@mwdh2o.com; Michael Mosley; phutton@mwdh2o.com; Lee, Petra@DWR; Stefanie.Morris@bbklaw.com; terlewine@swc.org; tmongan@gmail.com; Moricz, Nancy@DWR; gary.gill@pnnl.gov; mstephenson@mlml.calstate.edu
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Open Water Workgroup Methylmercury Control Study Workplan Concept Proposal

1. Problem Statement

The Sacramento/San Joaquin River Delta Total Maximum Daily Load (TMDL) establishes a Delta Mercury Control Program as a result of Basin Plan Amendment NO. R5-2010-0043. Each Delta subarea within the Delta and Yolo Bypass has been assigned an open water methylmercury (MeHg) load allocation in the Basin Plan. Open water allocations cover two areas: 1) water operations that may impact Delta in-channel mercury processes; and 2) flood management operations that may impact MeHg production in the Yolo Bypass. Additionally, the Central Valley Flood Protection Plan has identified flood management improvements that may impact open water processes in the Delta and Yolo Bypass. The Yolo Bypass and Sacramento River subareas have a 78% and 44% required allocation reduction, respectively, in the Delta Mercury Control Program.[1]

Unlike point sources or traditional non-point sources, operation of the State Water Project (SWP), Central Valley Project (CVP), and flood management operations do not easily lend themselves to control studies that can quantify changes in MeHg production as a function of operational modifications. In addition to difficulties that originate from the underlying nature of the projects, development of control studies are also made difficult because, in some cases, the basic processes that drive production and degradation of MeHg in the area have not been previously studied (for example the Yolo Bypass). Under these circumstances, the important drivers of MeHg production and the degradation in the system are not understood. This lack of knowledge makes it difficult to generate meaningful and testable hypotheses on how MeHg production would change if modifications were made to flood operations or State and Federal Water Project operations, or if an alternate conveyance were implemented.

Therefore, the Open Water workgroup proposes to use a modeling approach to examine the impacts of changes in project and flood operations on MeHg production and degradation.[2] This approach may provide a tool to examine whether proposed operational modifications could affect MeHg production and export, and whether modifications to management practices, if feasible, could decrease MeHg production. A scientific model could be used to gain insight into MeHg sources and the conditions that contribute to MeHg behavior in TMDL open waters. Additionally, data collected and used to calibrate and verify the model may provide meaningful insight into the processes in the Delta and Yolo Bypass that contribute to MeHg production and cycling.

2. Objectives

The Open Water workgroup's first major objective, in development of a MeHg control strategy, will be to develop a process-oriented biogeochemical model of mercury cycling that is driven by hydrodynamic water flows within the Delta. It is important to note that it will not be necessary to "start from scratch"

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[1] Table A, Attachment 1, Sacramento San Joaquin River Delta Mercury TMDL Resolution NO. R5-2010-0043. Percent reduction is calculated from the difference between the current load and the allocation.

[2] Final study costs will determine the extent of modeling questions to be answered.

(i.e., create a new model) as several hydrodynamic models, as well as models of biogeochemical mercury cycling, exist and could potentially be used for this effort (described later).

The workgroup's second major objective will be to use the combined hydrodynamic and mercury models to understand the importance of various biogeochemical mercury processes in influencing and controlling MeHg concentrations in water sediments and biota in different regions of the Delta. If the model can be calibrated and validated, we propose to use the model to test various flood and water management scenarios and to predict changes resulting from operational changes in the Delta and Yolo Bypass. Based on this modeling effort, we propose to generate specific hypotheses about mercury cycling and water supply and flood management.

Additionally, the Department of Water Resources (DWR) is currently studying sediment transport and mercury loads within the Cache Creek Settling Basin (CCSB) and lower Cache Creek Watershed under a separate TMDL. Because of the prominent role the CCSB basin plays on the load allocation in the Yolo Bypass, the Open Water workgroup recognizes that any mercury control efforts implemented for the CCSB will directly impact mercury loads into the Yolo Bypass. Therefore, the workgroup proposes to assess and evaluate the impact of control measures within the CCSB on Yolo Bypass MeHg production and concentration through modeling efforts (potentially by direct linkage between a model being developed for the CCSB by U.C. Davis, or through sensitivity analysis to provide a boundary term in the open water model). Finally, applicable studies conducted by the Central Valley Flood Protection Board for the recently adopted Central Valley Flood Protection Plan will be evaluated through modeling to determine their applicability to the open water areas of the Delta.

Flood control projects that have a habitat restoration component, for example reintroduction of a floodplain, could lend themselves to hypothesis testing and will be evaluated on a case-by-case basis. Additionally, open water entities responsible for leasing and/or permitting requirements for projects with the potential to disturb sediment within the Delta boundaries will evaluate those requirements to further comply with the TMDL.

3. Mechanisms Underlying the Study

The Non-Point Source workgroup produced a synthesis document that summarizes the state of the knowledge in the Delta and Yolo Bypass (Meyers and Ackerman, 2012). Process data have primarily been collected in the Delta. The Open Water workgroup believes these data are sufficient to begin the modeling process for the Delta region. However, very limited process data have been collected within the Yolo Bypass. Therefore, to develop a model to predict changes in MeHg production due to current or proposed changes in flood management, efforts for the Yolo Bypass must first focus on data collection (see Section 4 "Proposed Control Measures" for more information). This action supports the Knowledge Gaps' section in Meyers and Ackerman's 2012 Synthesis report, which recommends developing a modeling tool to test the usefulness of different management actions. A conceptual site model will be developed to demonstrate factors affecting MeHg within the study area and to show how the control study will achieve the control objectives. For example, the conceptual model may describe the transport of total mercury and MeHg in and out of the open water areas and transformation of total mercury to MeHg within the open water areas.

4. Proposed Control Measures

The use of a modeling approach will not be a targeted research or a pilot study, but will be much larger in scope. This multi-agency effort will create a tool that can be used, not only by the Open Water workgroup, but potentially by the entire Sacramento-San Joaquin Delta regulated MeHg community. With modeling, the Central Valley Regional Water Quality Control Board and other MeHg stakeholders can ask predictive questions about how changes to the Delta and Yolo Bypass system could affect MeHg production.

One risk associated with a modeling approach is that model predictions are only as accurate as the data used in the model and the accuracy of the model itself. The workgroup recognizes these challenges. With respect to the Delta and Yolo Bypass open water issues, modeling capabilities and data sources differ by location. Therefore, a phased approach, tailored to the needs of each open water element, is proposed. The goal of the phased approach is to create a model(s) that will demonstrate how MeHg production and concentration are affected under different open water operational scenarios and, if possible, serve as a springboard to identify different management practices for further testing.

Water quality and mercury process data already exist for some sections of the Delta; however, limited data exist for the Yolo Bypass. For the Delta, existing data will be used to validate model output and to identify data gaps. To facilitate modeling, the Delta may be subdivided into several subunits. This could simplify identification of data gaps and make evaluation of potential impacts resulting from flood control measures more manageable. If the model is able to predict known mercury results, then it will be used to examine the impacts on MeHg production as a function of proposed SWP and CVP operational modifications. If the model is unable to predict existing conditions, additional data will be collected in the Delta to provide a more accurate assessment of conditions. The model will then be rerun to verify its accuracy. Once model accuracy is established, impacts on MeHg production will be examined.

To facilitate modeling efforts for the Yolo Bypass, spatial and temporal biogeochemical process rate data will be collected to create mercury rate constants encompassing different seasons and years. It is anticipated that data collection would occur over 2 to 3 years. Following data collection, the modeling approach would be similar to Delta modeling, with Yolo Bypass questions focused on proposed changes to flood management operations.

General phases for both the Delta and the Yolo Bypass associated with the modeling approach are listed below:

1. Identify hydrodynamic model(s) for the Delta and Yolo Bypass.
2. Identify mercury modeling approach and mercury model requirements.

3. Model appropriate water quality simulations to verify model outputs.
4. Use model outputs to identify mercury process data gaps and sampling needs.
5. If necessary, collect additional data to provide information to fill identified data gaps.
6. If necessary, repeat steps 4 and 5 until modeled results agree with actual data.
7. Develop hypothesis to test.
8. Conduct modeling simulations using hypothesis developed in step 7.

Mercury modeling of the open water system requires modeling of both the hydrodynamics of the system as well as mercury biogeochemical cycling processes. Models that could be used to model the hydrodynamics of the system include, but are not limited to: the Delta Simulation Model 2 (DSM2), HydroGeoSphere, the Environmental Fluid Dynamics Code (EFDC), ADaptive Hydraulics Model (ADH), MIKE-21, or RMA.

There are several mercury biogeochemical cycling models that may be appropriate for this effort. The models include, but are not limited to, 1) the Dynamic Mercury Cycling Model (D-MCM), which was developed by the Electric Power Research Institute and has been utilized for nearly two decades to understand mercury behavior, cycling, and bioaccumulation into the food web in the Great Lakes, Everglades, Gulf of Mexico and other locations internationally (Hudson et al., 1994; Harris et al., 2007), and 2) the United States Environmental Protection Agency's (U.S. EPA's) Water Quality Analysis Simulation Program (WASP) model (http://www.epa.gov/athens/wwqtsc/html/wasp.html). WASP is a generalized mass balance model that can be used for a range of substances and has been used to investigate the aquatic cycling of mercury (Knights et al., 2009). Several models may be freely available for public use.

The workgroup will evaluate two options for model development: a) using temporal and spatial flow output from a hydrodynamic model as input to a mercury biogeochemical cycling model, and b) directly incorporating mercury biogeochemical process algorithms into the hydrodynamic model

5. Monitoring and Data Collection Plan

There currently exists a reasonable amount of water quality and mercury data for the Delta region that were largely obtained during the CALFED Mercury Program. Some of these data are in peer-reviewed literature or are available from reports and web sites (e.g. http://mercury.mlml.calstate.edu/). This existing field data will be used to conduct initial model development and testing. It is recognized that broad scale temporal and spatial data of mercury biogeochemical processes do not exist for all regions of the Delta. We propose to use initial model development and sensitivity analysis to determine where, and what kind, of data gaps exist. Where critical information is needed to better inform and calibrate the model, a field data collection plan will be developed to obtain the necessary temporal and spatial data.

The accuracy and effectiveness of the model will be evaluated by comparing predicted spatial and temporal trends with existing field data and with spatial and temporal trends in those major biogeochemical processes that are known to govern mercury behavior and transport. Once there is agreement that the model is providing an accurate description of mercury behavior and transport in the Delta, it will be used to examine operational and management hypotheses.

Based on previous mercury research in California and other areas, we anticipate that temporal and spatial field data in the following areas may be necessary to better inform the model in addressing these mercury processes:

- Methylmercury photodegradation
- Mercury methylation rates in sediments
- Sediment-Water Exchange Fluxes
- Biological incorporation
- Particle-Water Interactions
- Atmospheric input

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Open Water Workgroup Methylmercury Control Study Workplan Concept Proposal

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