Delta Regional Monitoring Program

Quality Assurance Project Plan

Version 4.2
November 19, 2018

Prepared by
Thomas Jabusch, Don Yee, John Ross, Amy Franz, and Matthew Heberger
San Francisco Estuary Institute-Aquatic Science Center
4911 Central Avenue
Richmond, CA 94804

SFEI | AQUATIC SCIENCE CENTER

1 Title and Approval

For

PROJECT NAME: Delta Regional Monitoring Program

Date: November 21, 2018

NAME OF RESPONSIBLE ORGANIZATION: San Francisco Estuary Institute – Aquatic Science Center (SFEI-ASC)

1.1 Approval Signatures

Title:	Name:	Signature:	Signature Date:
SFEI-ASC Program Manager / Contract Manager	Matthew Heberger	Matthew Heberger	12/3/2018
SFEI-ASC QA Officer	Don Yee	Don Yee	12/10/18
SFEI-ASC Data Manager	Amy Franz	A. Franz	12/3/18
Assistant Deputy Director SWRCB Office of Information Management and Analysis	Melissa Morris	on file	2018-12-05
~~SWRCB QA Officer~~	~~Renee Spears~~	Not available to review	
MPSL Project Manager	Wes Heim	on file	2018-12-18
MPSL QA Officer	Autumn Bonnema	on file	2018-12-18
~~U~~SGS Project Chief	Brian Bergamaschi	on file	2018-12-18
USGS Project Chief	Jim Orlando	on file	2018-11-23
USGS Program Chief	Joe Domagalski	on file	2018-12-18
Delta RMP SC co-Chair	Adam Laputz	on file	2019-01-02
Delta RMP SC co-Chair	Debbie Webster	on file	2019-01-09

2 Table of Contents

2.1 List of Tables

2.2 List of Figures

2.3 Acronyms and Abbreviations

Ap	particulate absorbance
AHPL	Aquatic Health Program Laboratory at UC Davis
ASC	Aquatic Science Center
ASTM	An international standards organization, formerly American Society for Testing and Materials
BPA	Basin Plan Amendment
BGC	Biogeochemistry
BrCl	bromine chloride
CA	California
CAS	Chemical Abstracts Service
CD3	Contaminant Data, Display and Download Tool
CEDEN	California Environmental Data Exchange Network
CFR	Code of Federal Regulations
chl-a	chlorophyll a
COC	chain of custody
COLD	Cold Freshwater Habitat Beneficial Use
COMM	Commercial and Sport Fishing Beneficial Use
CRM	certified reference material
CSD	Community Services District
CVCWA	Central Valley Clean Water Agency
CVRWQCB	Central Valley Regional Water Quality Control Board
DA	discriminant analysis
DFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
DI	deionized water
DOC	dissolved organic carbon
DOI	Digital Object Identifier System
DPR	California Department of Pesticide Regulation
DQI	data quality indicator
DQO	data quality objectives
dw	dry weight
DWR	Department of Water Resources
EDD	Electronic Data Deliverable
EMP	Environmental Monitoring Program
EDTA	Ethylenediaminetetraacetic acid
EMPC	Estimated maximum possible concentration
EPTC	A pesticide, also referred to as Eradicane, Eptam, and other names. CAS Registry Number: 759-94-4.
EST	Estuarine Habitat Beneficial Use
fDOM	fluorescent dissolved organic matter
FNU	Formazin Nephelometric Units
FS	Forecasting scenarios

FY	fiscal year
g	gram
GC	gas chromatography
GLP	good laboratory practices
GPS	global positioning system
GRTS	Generalized Random Tessellation Stratified
h	hours
HCl	hydrochloric acid
Hg	mercury
Hz	Hertz
H2SO4	sulphuric acid
ID	identification
ISUS	In situ Ultraviolet Spectrophotometer
KCl	potassium chloride
LC50	Lethal concentrations that kills 50% of test animals during an observation period
LCS	laboratory control sample
LRM	laboratory reference material
LWA	Larry Walker Associates
m	meter
m/s	meters per second
MDL	Method detection limit
MEI	McCord Environmental Inc.
MeHg	methylmercury
mg/kg	milligram per kilogram
mg/L	milligram per liter
MIGR	Fish Migration Beneficial Use
MLML	Moss Landing Marine Laboratory
mm	millimeter
MPSL	Marine Pollution Studies Laboratory
MQO	measurement quality objective
MS	matrix spike
MS4	Municipal Separate Storm Sewer System
MSD	matrix spike duplicate
MUN	Municipal and Domestic Water Supply Beneficial Use
MWD	Metropolitan Water District
n/a, NA	not applicable
N	nitrogen or normal (e.g. 12N HCl)
NBC	Not blank corrected
NDT	Nondestructive Testing
NFM	National Field Manual for the Collection of Water-Quality Data
ng	nanogram
NIST	National Institute of Standards and Technology
nm	nanometer

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO3-N	nitrate nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCC	National Registry of Certified Chemists
NWIS	National Water Information System
NWQL	USGS National Water Quality Laboratory
OA	Oxygen Analog
OCRL	USGS Organic Chemistry Research Laboratory
OEHHA	California Office of Environmental Health Hazard Assessment
OFR	USGS Open-File Report
OFW	organic free water
OMRL	USGS Organic Matter Research Laboratory
OSHA	Occupational Safety and Health Administration
P	phosphorus
p	probability
PARAFAC	parallel factor analysis
PBO	Piperonyl Butoxide
PC	Project Coordinator
PCA	principal component analysis
PCNB	Pentachloronitrobenzene
PFRG	USGS Pesticide Fate Research Group
pH	potential of hydrogen
PI	Principal Investigator
PIC	Particulate Inorganic Carbon
POC	particulate organic carbon
POD	Pelagic Organism Decline
POTW	public owned treatment works
PPE	personal protection equipment
ppm/yr	parts per million per year
PTI	Pesticide Toxicity Index
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QB	quality assurance blank sample
QC	quality control
QREC	quality assurance recovery
QSE	quinine sulfate equivalent
R^2	coefficient of determination
R/V	Research Vessel

RDC	Regional Data Center
REC1	Water Contact Recreation Beneficial Use
REC2	Noncontact Water Recreation Beneficial Use
RL	reporting limit
RMP	Regional Monitoring Program
RPD	relative percent difference
RSD	relative standard deviation
S/N	signal-to-noise
SC	Steering Committee
SD	Sanitary District
SFCWA	State and Federal Contractors Water Agency
SFEI	San Francisco Estuary Institute
SJR	San Joaquin River
SOP	standard operating procedure
SPLP	sources, pathways, loadings, and processes
SPWN	Fish Spawning Beneficial Use
SRM	standard reference material
ST	Status and Trends
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee or Test Acceptability Criteria
TIE	Toxicity Identification Evaluation
TM	Technical method(s)
TMDL	Total Maximum Daily Load
TPN	total particulate nitrogen
TPC	total particulate carbon
TOC	total organic carbon
TSS	total suspended solids
TWRI	Techniques of Water-Resources Investigations, a series of USGS publications
U.S. EPA	United States (U.S.) Environmental Protection Agency
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
v:v	volume-to-volume
VSS	volatile suspended solids
WARM	Warm Freshwater Habitat Beneficial Use
WDL	Water Data Library
WDR	Waste Discharge Requirement
WILD	Wildlife Habitat Beneficial Use
WQ	water quality
WT	water tracing
ww	wet weight
YSI	A water quality instrument manufacturer, formerly Yellow Springs Instrument Company

µg	microgram
µm	micrometer
µS/cm	micro-Siemens per centimeter
µM	micro-Molar
°C	degrees Celsius

3 Distribution List

The organizations and persons listed in Table 3.1 will receive a copy of the approved QA Project Plan and any subsequent revisions.

Table 3.1 Distribution list

Name	Affiliation	Title	Phone	Email Address
Selina Cole	CVRWQCB	Delta RMP Staff	(916) 464-4683	Selina.Cole@waterboards.ca.gov
Patrick Morris	CVRWQCB	Delta RMP Staff	(916) 464-4621	Patrick.Morris@waterboards.ca.gov
Wes Heim	MPSL	PI/Project Manager	(831) 771-4459	wheim@mlml.calstate.edu
Autumn Bonnema	MPSL	Project Coordinator/ QA Officer	(831) 771-4175	bonnema@mlml.calstate.edu
Adam Laputz	SC	Representative – Regulatory (State)	(916) 464-4848	Adam.laputz@waterboards.ca.gov
Greg Gearheart	SC	Representative – Regulatory (State)	(916) 341-5892	Greg.Gearheart@waterboards.ca.gov
Terry Fleming	SC	Representative – Regulatory (Federal)	(415) 972-3462	fleming.terrence@epa.gov
Gregg Erickson	SC	Representative – Coordinated Monitoring	(209) 942-6071	gerickson@dfg.ca.gov
Dave Tamayo	SC	Representative – Stormwater, Phase I	(916) 874-8024	tamayod@saccounty.net
Brendan Ferry	SC	Representative – Stormwater, Phase II	(530) 573-7905	Brendan.ferry@edcgov.us
Stephanie Reyna-Hiestand	SC	Representative – Stormwater, Phase II	(209) 831-4333	Stephanie.hiestand@ci.tracy.ca.us
Samsor Safi	SC	Representative – POTWs	(916) 876-6030	safis@sacsewer.com
Deedee Antypas	SC	Representative – POTWs	(205) 937-7425	deedee.antypas@stocktonca.gov
Josie Tellers	SC	Representative – POTWs	(530) 747-8291	jtellers@cityofdavis.org
David Cory	SC	Representative – Agriculture	(209) 658-5854	farmeratlaw@comcast.net

Name	Affiliation	Title	Phone	Email Address
Mike Wackman	SC	Representative – Agriculture	(209) 472-7127 ext. 125	michaelkw@msn.com
Melanie Okoro	SC	Representative – Resource Agencies	(916) 930-3728	Melanie.Okoro@noaa.gov
Melissa Morris	SWRCB	Assistant Deputy Director, OIMA	(916)-341-5868	melissa.morris@waterboards.ca.gov
Brian Bergamaschi	USGS	Co-PI	(916) 278-3053	bbergama@usgs.gov
Bryan Downing	USGS	Co-PI	(916) 278-3292	bdowning@usgs.gov
Tamara Kraus	USGS	Co-PI	(916) 278-3260	tkraus@usgs.gov
Amanda Egler	USGS	QA/QC Officer	916-278-3210	alegler@usgs.gov
Jim Orlando	USGS	Project Chief	916-278-3271	jorlando@usgs.gov
Joe Domagalski	USGS	Program Chief	916-278-3077	joed@usgs.gov
Marie Stillway	UC Davis AHPL	Lab Director		
Matthew Heberger	SFEI-ASC	Program Manager	(510) 746-7391	matth@sfei.org
Amy Franz	SFEI-ASC	Data Manager	(510) 746-7394	amy@sfei.org
Don Yee	SFEI-ASC	QA Officer	(510) 746-7369	donald@sfei.org

4 Project Task/Organization

This Quality Assurance Program Plan (QA Project Plan or QAPP) has been prepared for the monitoring of surface water quality in the Sacramento-San Joaquin River Delta (the Delta) by the Delta Regional Monitoring Program (Delta RMP). This section of the QA Project Plan describes how the project will be managed, organized and implemented.

The responsible agency for this surface water monitoring program is the San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC), acting as the implementing entity to the Delta RMP. The program is managed by a Steering Committee and advised by a Technical Advisory Committee. SFEI-ASC staff contracts with, and partners with, several agencies and laboratories to carry out monitoring activities. Roles and responsibilities are shown in Figure 4.1 and described in more detail in the following sections.

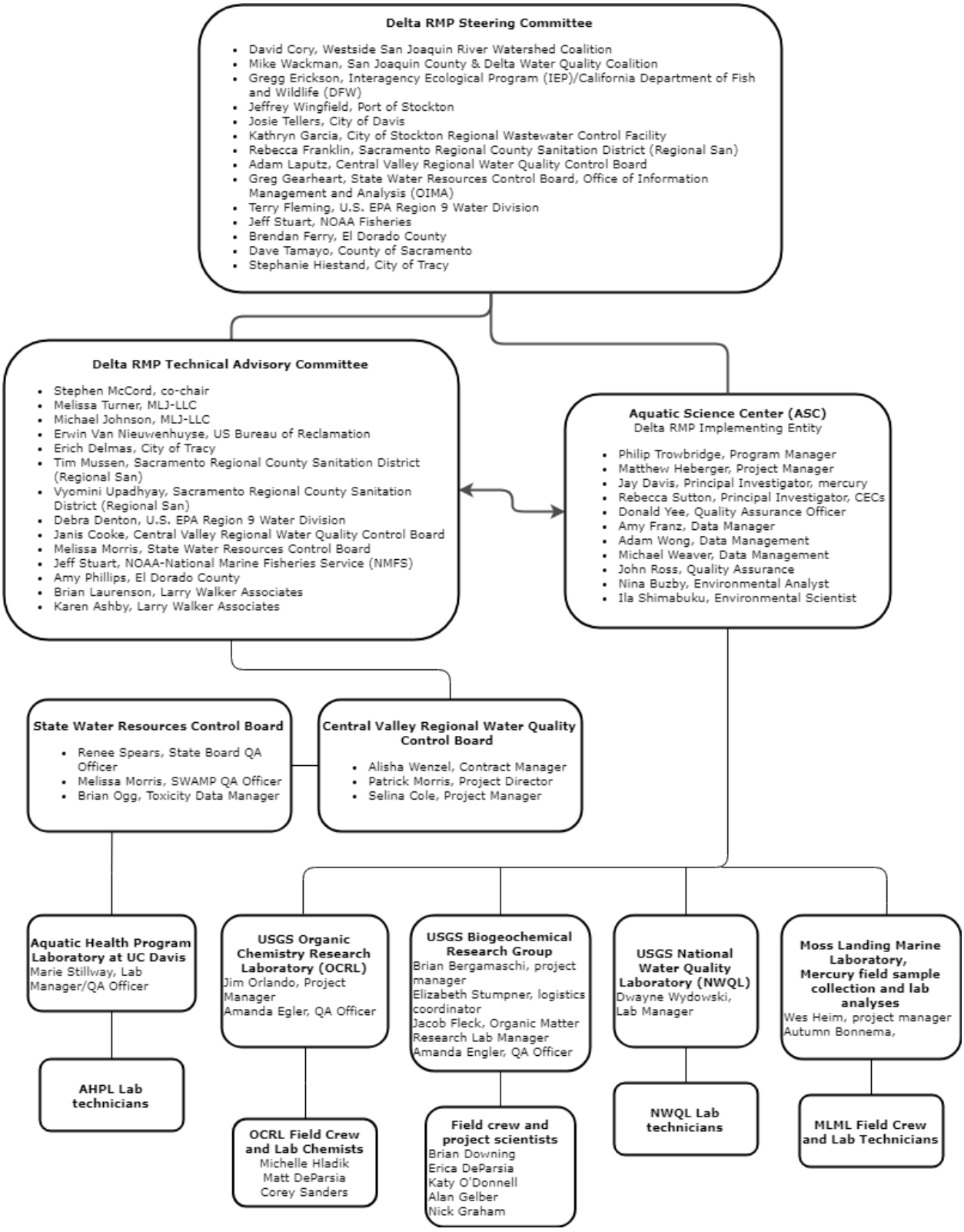

Figure 4.1 Delta Regional Monitoring Program organization chart.

4.1 Principal Data Users and Stakeholders

Principal data users include internal (program participants) and external stakeholders (other Delta managers and policymakers, local scientists and the scientific community at large, and the public). Participants include regulatory agencies, resource agencies, water supply, coordinated monitoring programs, wastewater treatment plants, stormwater municipalities, irrigated agriculture coalitions, and dredgers (Appendix A). Fiscal Year 2018/2019 (FY187/19) funding for the Delta RMP is provided by the wastewater treatment plants, stormwater municipalities, irrigated agriculture coalitions, and dredgers listed in Appendix A. FY18/19 funding also includes in-kind support from the Central Valley Regional Water Quality Control Board via funding from the Surface Water Ambient Monitoring Program (SWAMP). The Aquatic Science Center (ASC) serves as the fiscal agent of the Delta RMP.

4.2 Project Team

An organizational chart, with monitoring responsibilities noted, is provided in Figure 4.1 above.

4.2.1 Steering Committee

The Delta Regional Monitoring Program (Delta RMP) Steering Committee (Table 4.1) is the decision-making body of the Delta RMP. The Steering Committee is responsible for establishing the Delta RMP's strategic direction and the policies and procedures that govern its operation. The Steering Committee may direct Delta RMP staff and advisory committees to assist in meeting program objectives and may delegate day-to-day functions of the Delta RMP to the Delta RMP's implementing entity.

Table 4.1 Delta RMP Steering Committee members

Name	Affiliation	Representing	Position
David Cory	Westside San Joaquin River Watershed Coalition	Agriculture (2 seats)	Primary
Mike Wackman	San Joaquin County & Delta Water Quality Coalition	Agriculture (2 seats)	Primary
Bruce Houdesheldt	Sacramento Valley Water Quality Coalition	Agriculture (2 seats)	Alternate
Parry Klassen	East San Joaquin Water Quality Coalition	Agriculture (2 seats)	Alternate
Gregg Erickson	Interagency Ecological Program (IEP)/California Department of Fish and Wildlife (DFW)	Coordinated Monitoring (1 seat)	Primary
Erwin Van Nieuwenhuyse	Interagency Ecological Program (IEP)/US Bureau of Reclamation	Coordinated Monitoring (1 seat)	Alternate
Karen Gehrts	Interagency Ecological Program (IEP)/California Department of Water Resources (DWR)	Coordinated Monitoring (1 seat)	Alternate
Jeffrey Wingfield	Port of Stockton	Dredgers (1 seat)	Primary

Name	Affiliation	Representing	Position
Josie Tellers	City of Davis	POTW (3 seats)	Primary
Kathryn Garcia	City of Stockton Regional Wastewater Control Facility	POTW (3 seats)	Primary
Rebecca Franklin	Sacramento Regional County Sanitation District (Regional San)	POTW (3 seats)	Primary
Casey Wichert	City of Brentwood	POTW (3 seats)	Alternate
Debbie Webster	Central Valley Clean Water Association	POTW (3 seats)	Alternate
Deedee Antypas	City of Stockton Regional Wastewater Control Facility	POTW (3 seats)	Alternate
Jenny Skrel	Ironhouse Sanitary District	POTW (3 seats)	Alternate
Nader Shareghi	Mountain House CSD	POTW (3 seats)	Alternate
Samsor Safi	Sacramento Regional County Sanitation District (Regional San)	POTW (3 seats)	Alternate
Tom Grovhoug	Larry Walker and Associates (LWA)	POTW (3 seats)	Alternate
Tony Pirondini	City of Vacaville	POTW (3 seats)	Alternate
Vyomini Upadhyay	Sacramento Regional County Sanitation District (Regional San)	POTW (3 seats)	Alternate
Adam Laputz	Central Valley Regional Water Quality Control Board	Regulatory Agencies (3 seats)	Primary
Greg Gearheart	State Water Resources Control Board, Office of Information Management and Analysis (OIMA)	Regulatory Agencies (3 seats)	Primary
Terry Fleming	U.S. EPA Region 9 Water Division	Regulatory Agencies (3 seats)	Primary
Melissa Morris	State Water Resources Control Board	Regulatory Agencies (3 seats)	Alternate
Pamela Creedon	Central Valley Regional Water Quality Control Board	Regulatory Agencies (3 seats)	Alternate
Valentina Cabrera-Stagno	U.S. EPA Region 9 Water Division	Regulatory Agencies (3 seats)	Alternate
Jeff Stuart	NOAA Fisheries	Resource Agencies (1 seat)	Primary
Brendan Ferry	El Dorado County	Stormwater Agencies (3 seats)	Primary
Dave Tamayo	County of Sacramento	Stormwater Agencies (3 seats)	Primary
Stephanie Hiestand	City of Tracy	Stormwater Agencies (3 seats)	Primary
Brandon Nakagawa	County of San Joaquin	Stormwater Agencies (3 seats)	Alternate

Name	Affiliation	Representing	Position
Dalia Fadl	City of Sacramento	Stormwater Agencies (3 seats)	Alternate

The Steering Committee authorizes the implementation of agreements among the participating members and, specifically:

1. Directs the fiscal/operating agent to request and receive federal, state, local, and private funds from any source and to expend those moneys to accomplish the Delta RMP's goals
2. Approves budgets and expenditures
3. Directs the fiscal/operating agent to enter into partnerships, contracts, and other legal agreements on behalf of the Delta RMP, as necessary to fulfill the Delta RMP's mission
4. Approves Delta RMP work products and any other plans, products, or resolutions of the Delta RMP
5. Sets priorities and oversee the activities of the Technical Advisory Committee
6. Establishes and oversees the implementation of policies and procedures necessary to the day-to-day functioning of the Delta RMP

4.2.2 Technical Advisory Committee

Under the direction of the Delta Regional Monitoring Program (Delta RMP) Steering Committee, the Technical Advisory Committee (TAC) provides technical oversight of the Delta RMP. The membership of the TAC is shown in Table 4.2 below.

Table 4.2 Delta RMP Technical Advisory Committee.

Name	Affiliation	Representing	Position
Stephen McCord	MEI	Chairperson	Co-chair
Melissa Turner	MLJ Environmental	Agriculture (2 seats)	Primary
Michael Johnson	MLJ Environmental	Agriculture (2 seats)	Primary
Erwin Van Nieuwenhuyse	US Bureau of Reclamation	Coordinated Monitoring (1 seat)	Primary
Joe Domagalski	U.S. Geological Survey	Coordinated Monitoring (1 seat)	Alternate
Shaun Philippart	CA Department of Water Resources	Coordinated Monitoring (1 seat)	Alternate
Erich Delmas	City of Tracy	POTW (3 seats)	Primary

Name	Affiliation	Representing	Position
VACANT		Dredgers (1 seat)	Primary
Tim Mussen	Sacramento Regional County Sanitation District (Regional San)	POTW (3 seats)	Primary
Vyomini Upadhyay	Sacramento Regional County Sanitation District (Regional San)	POTW (3 seats)	Primary
Cam Irvine	Roberston Bryan Inc.	POTW (3 seats)	Alternate
Lisa Thompson	Regional San	POTW (3 seats)	Alternate
Debra Denton	U.S. EPA Region 9 Water Division	Regulatory Agencies (3 seats)	Primary
Janis Cooke	Central Valley Regional Water Quality Control Board	Regulatory Agencies (3 seats)	Primary
Melissa Morris	State Water Resources Control Board	Regulatory Agencies (3 seats)	Primary
Bev Anderson-Abbs	State Water Resources Control Board	Regulatory Agencies (3 seats)	Alternate
Danny McClure	Central Valley Regional Water Quality Control Board	Regulatory Agencies (3 seats)	Alternate
Dawit Tadesse	State Water Resources Control Board	Regulatory Agencies (3 seats)	Alternate
Jessica Mullane	Central Valley Regional Water Quality Control Board	Regulatory Agencies (3 seats)	Alternate
Selina Cole	Central Valley Regional Water Quality Control Board	Regulatory Agencies (3 seats)	Alternate
Valentina Cabrera-Stagno	U.S. EPA Region 9 Water Division	Regulatory Agencies (3 seats)	Alternate
Jeff Stuart	NOAA-National Marine Fisheries Service (NMFS)	Resource Agencies (1 seat)	Primary
Amy Phillips	El Dorado County	Stormwater Agencies (3 seats)	Primary
Brian Laurenson	Larry Walker Associates	Stormwater Agencies (3 seats)	Primary
Karen Ashby	Larry Walker Associates	Stormwater Agencies (3 seats)	Primary
Hope McCaslin Taylor	Larry Walker Associates	Stormwater Agencies (3 seats)	Alternate
Stephen Clark	Pacific Eco Risk	Stormwater Agencies (3 seats)	Alternate

4.2.3 Implementing Entity

The San Francisco Estuary Institute – Aquatic Science Center (SFEI-ASC) manages and operates the program. The SFEI-ASC Program Manager (Matthew Heberger) is responsible for coordinating monitoring components of this project including the organization of field sampling, interactions with the contract laboratories, and managing laboratory subcontracts. The SFEI-ASC Program Manager reports directly to the Delta RMP Steering Committee.

The SFEI-ASC Regional Data Center Manager (Amy Franz) coordinates the SFEI-ASC Data Services Team, which performs data review and validation to ensure that data submitted by subcontractor labs are timely, complete, and properly incorporated into the Regional Data Center database.

SFEI-ASC's Quality Assurance Officer (QAO, Don Yee) role is to provide Quality Assurance oversight and to review and approve the quality assurance and quality control (QA/QC) procedures found in this QAPP, which include field and laboratory activities. The SFEI QAO will work with the Quality Assurance Officers for contracted analytical laboratories, reviewing and communicating all QA/QC issues contained in this QAPP to the laboratories.

4.2.4 Field Crews and Laboratories

Laboratories contracted by SFEI-ASC (Table 4.3) provide analytical services and will act as a technical resource to SFEI-ASC staff and management.

Table 4.3 Analytical laboratories.

Analytical laboratory	Lab abbrev.	Matrix	Analytical Services	Lab QA Manual Link
Marine Pollution Studies Lab, Moss Landing Marine Labs	MPSL	Sediment, Tissue, Water	Fish attributes, mercury, suspended solids, sediment	MPSL Laboratory QAP, Revision 7. November 2016[1]
U.S. Geological Survey National Water Quality Laboratory	USGS-NWQL	Water	Nutrients, chl-*a*, phaeopigments[2] Copper, DOC, PIC, POC, TPC, and TPN	Quality Assurance and Quality Control
U.S. Geological Survey Organic Matter Research Laboratory	USGS-OMRL	Water	Dissolved organic carbon (DOC), optical measurements, particulate absorbance (A_p)	n/a[3]
U.S. Geological Survey Organic Chemistry Research Laboratory	USGS-OCRL	Water	Current Use Pesticides Chemistry	n/a[4]
University of California Davis-Aquatic Health Program Laboratory	UCD-AHPL	Water	Aquatic Toxicity, Toxicity Identification Evaluations	UCD AHPL QAM

Mercury

Marine Pollution Studies Lab/Moss Landing Marine Labs will analyze tissue, sediment, and water for the mercury component.

Autumn Bonnema will serve as the MPSL Project Coordinator (PC). She will 1) review, evaluate, and document project reports, and 2) verify the completeness of all tasks. She may also assist field crew in preparation and logistics.

Billy Jakl of MPSL is in charge of directing fish, water, and sediment collection for mercury monitoring. He will 1) oversee preparation for sampling, including vehicle maintenance, and 2) oversee sample and field data collection.

[1] Contact MPSL Laboratory QAO (Table 0.1) to obtain a copy.

[2] Degradation products of algal chlorophyll pigments.

[3] USGS-OMRL currently has no standalone document describing general QA procedures. The existing QA procedures have been incorporated into the Delta RMP QAPP, as appropriate, and are also documented in SOPs.

[4] USGS-OCRL currently has no standalone document describing general QA procedures. The existing QA procedures have been incorporated into the Delta RMP QAPP, as appropriate, and are also documented in SOPs.

Stephen Martenuk is the MPSL laboratory manager. His duties will be to ensure that laboratory technicians have processing instructions and that all laboratory activities are completed within the proper timelines. He is also responsible for sample storage and custody at MPSL.

Wes Heim will serve as the project manager for the MPSL-DFW component of this project. His specific duties will be to 1) review and approve the QAPP, 2) provide oversight for mercury analyses to be done for this project, 3) ensure that all MPSL-DFW activities are completed within the proper timelines, and 4) oversee data validation, management, and reporting.

Nutrients

Brian Bergamaschi is project manager and field lead for USGS, Bryan Downing and Elizabeth Stumpner are alternate field leads. The USGS boat crew for all three days will include any of the following members of the Biogeochemistry (BGC) group: Brian Bergamaschi, Bryan Downing, Katy O'Donnell, Nick Graham, Jessa Rego, Liz Stumpner.

Liz Stumpner is the point of contact for the USGS National Water Quality Laboratory (NWQL). Sharon Gosselink and Annie Quratulain will complete laboratory processing and shipment to the USGS NWQL and any other labs.

Jacob Fleck is the USGS Organic Matter Research Laboratory (OMRL) laboratory manager and Duane Wydoski is the USGS NWQL laboratory manager. Their duties will be to ensure that laboratory technicians have processing instructions and that all laboratory activities are completed within the proper timelines. They are also responsible for sample storage and custody at their labs.

Pesticides

Jim Orlando is the project manager at the USGS Organic Chemistry Research Laboratory (OCRL). His duties will be to ensure that all project elements meet the guidelines established in the QAPP and project contract. He is responsible for the final review of all project analytical results produced by the OCRL. He serves as the primary contact between the Delta RMP and the OCRL and provides project updates to the cooperator.

Michelle Hladik is the Chief Chemist at the USGS OCRL and supervises all laboratory activities. Her duties will be to ensure that laboratory technicians have processing instructions and that all laboratory activities are completed following established guidelines (project specific QAPP and OCRL SOPs). She is responsible for sample analysis, initial review of the data, and provides data to the USGS project manager for review.

Corey Sanders is the chemist/database manager for the USGS OCRL. His duties will be to ensure that all sample collection information and analytical results are entered into the OCRL internal database and that this information is subsequently formatted and transferred to the

USGS National Water Information System (NWIS) database. He is also responsible for sample storage and custody at OCRL.

Matt DeParsia is the OCRL field technical lead for the project. His duties will be to ensure that water quality sampling is conducted following documented procedures (as described in the USGS *National Field Manual*, and this project-specific QAPP). He is also responsible for the initial processing of water samples at the OCRL and for shipping samples to the USGS National Water Quality Laboratory in Denver for additional chemical analyses that are not performed at the OCRL in Sacramento.

Toxicity

Marie Stillway is the Laboratory Manager of the Aquatic Health Program Laboratory (AHPL) at UC Davis. Her duties will be to ensure that aquatic toxicity testing is conducted following documented procedures outlined in this document, SWAMP Measurement quality objectives (MQOs), and laboratory-specific Standard Operating Procedures (SOPs). Ms. Stillway is also responsible for overseeing calculation and compilation of the toxicity data and providing these data to the data managers at the State Water Resources Control Board's Information Management & Quality Assurance (SWAMP IQ) unit. Additionally, Ms. Stillway will provide additional reporting data (such as copies of bench sheets and reference toxicity control charts) to the program manager for sharing with the Delta RMP Technical Advisory Committee.

The State Water Resource Control Board's Information Management & Quality Assurance (SWAMP IQ) unit will assume all data management responsibilities for Delta RMP toxicity data. This includes data processing, QA/QC review, and uploading the data to the California Environmental Data Exchange Network (CEDEN). Responsible parties include Brian Ogg, Environmental Scientist, and Tessa Fojut, SWAMP QA Officer.

Because SWAMP is funding the toxicity analyses and managing these data, SWAMP staff have indicated that they will upload the Delta RMP toxicity data to CEDEN and make the data publicly available without going through the same review and approval steps that govern the release of other Delta RMP datasets as outlined in the Communications Plan.

In the event that there are changes to the data *after* it has been published, changes will be communicated to data users in a timely manner. This is particularly important to members of the agricultural community who need it to fulfill requirements of the Irrigated Lands Regulatory Program. ASC has set up an email listserv to communicate any changes or updates to Delta RMP toxicity data. If State Water Board staff make any changes to these data after it has been published, Board staff should let ASC know so that staff can send out a notice to this group.

4.3 Persons Responsible for QAPP Update and Maintenance

Changes and updates to this QAPP may be made by SFEI-ASC's Program Manager and SFEI-ASC's QAO, after they review the evidence for change, and with the concurrence of the Delta RMP TAC. SFEI-ASC's QAO will be responsible for making the changes, submitting drafts for review, preparing a final copy, and submitting the final QAPP for signatures. The project plan will be reviewed on an annual basis. Changes are expected year to year in the early years of Delta RMP implementation.

5 Problem Definition/Background

The Delta RMP was initiated in 2008 by the Central Valley Regional Water Quality Control Board (Regional Water Board) with the primary goal of tracking and documenting the effectiveness of beneficial use protection and restoration efforts through comprehensive monitoring of water quality constituents and their effects in the Delta. The development of the Delta RMP was initially prompted by the collapse of the populations of several species of fish in the early 2000s, an event that triggered new inquiries into the potential role of contaminants in what is now termed the Pelagic Organism Decline (POD). However, these inquiries highlighted shortcomings of existing monitoring efforts to address questions at the scale of the Delta. The recognition that data from current monitoring programs were inadequate in coverage, could not easily be combined, and were not adequate to support a rigorous analysis of the role of contaminants in the POD persuaded regulatory agencies to improve coordination across multiple monitoring programs.

In addition, the Delta RMP reflects an increasing desire among water quality and resource managers throughout the state for more integrated information about patterns and trends in ambient conditions across watersheds and regions. Many stressors on beneficial uses are interrelated and must be addressed more holistically. The Delta RMP complements existing larger-scale collaborative monitoring efforts throughout the state that attempt to address questions and concerns about regional conditions and trends (e.g., San Francisco Bay RMP, Southern California Bight Monitoring Program, Surface Water Ambient Monitoring Program).

The Delta RMP Steering Committee decided at its December 3, 2012 meeting that the initial Delta RMP would focus on mercury, nutrients, pathogens, and pesticides, since these constituents represent high priority issues for management that are shared concerns of represented participant groups. The TAC subsequently developed monitoring designs for these priorities that would address the Delta RMP management questions (Appendix B, page 161) and priority assessment questions for each constituent (Appendix C, page 162).

Pesticides monitoring began in FY15/16 to provide information on spatial and temporal variability of pesticides and toxicity.

Mercury monitoring began in FY16/17 in order to address the highest priority information needs related to the implementation of the Methylmercury TMDL.

Nutrients are associated with excessive growth of nuisance aquatic vegetation that interferes with navigation, recreation, and can block water supply intakes. It is also suspected to contribute to harmful algal blooms (HABs) that produce toxins that kill fish and wildlife and are detrimental to drinking water quality and human health. Finally, nutrients play an important role in ecosystem health, for example by affecting primary productivity by algae which form the base of the food chain. Water managers seek to better understand these factors in order to better manage ecosystems and craft more effective plans for the conservation and recovery of threatened and endangered species in the Delta. Nutrient monitoring began in FY17/18 with a one-year special study to assess spatial variability of nutrients and related water quality constituents in the Delta at the landscape scale.

5.1 Core Management Questions

5.1.1 Pesticides and Aquatic Toxicity

A better understanding of the effects of contaminants in the apparent decline of Delta ecosystems is a priority for regulators and stakeholders. Pesticide use in the Delta and Central Valley generally is one of the potential drivers of these effects. Constantly changing pesticide use presents a challenge for environmental scientists, resource managers, and policy makers trying to understand whether these contaminants are impacting aquatic systems and if so, which pesticides appear to be the biggest problem. Less than half of the pesticides currently applied in the Central Valley are routinely analyzed in monitoring studies and new pesticides are continually being registered for use. Therefore, baseline monitoring of ambient surface water for both aquatic toxicity and a broad list of current use pesticides is needed to understand whether current use pesticides contribute to observed toxicity in the Delta.

The monitoring is intended to provide useful information to state and federal water quality regulators. Important regulatory drivers are described below.

Water Quality Control Plan for Sacramento River and San Joaquin River Basin (Basin Plan)

According to the State Water Board, the Basin Plan is "the Board's master water quality control planning document. It designates beneficial uses and water quality objectives for waters of the State, including surface waters and groundwater. It also includes programs of implementation to achieve water quality objectives."

The Central Valley Basin Plans states that, "in addition to numerical water quality objectives for toxicity, the Basin Plan contains a narrative water quality objective that requires all surface waters to '...be maintained free of toxic substances in concentrations that are toxic to or that produce detrimental physiological responses to human, plant, animal, and aquatic life.' To

check for compliance with this objective, the Regional Water Board initiated a biotoxicity monitoring program to assess toxic impacts from point and nonpoint sources in FY 86-87" (CVRWQCB 2016, IV-32.08). The plan states that the Regional Board "will continue to impose toxicity testing monitoring requirements in National Pollutant Discharge Elimination System (NPDES) permits. The focus of ambient toxicity testing will continue to be the Delta and major tributaries." In other words, the Board is interested in verifying that there are "no toxics in toxic amounts" in waterways, and will continue to require aquatic toxicity testing as a key means of making this determination.

Organophosphate TMDL

In 2006, the Central Valley Regional Water Quality Control Board identified Delta waterways as impaired under the federal Clean Water Act Section 303(d) due to elevated concentrations of the organophosphate pesticides diazinon and chlorpyrifos and created a plan for their allowable discharge to the Delta referred to as the Total Maximum Daily Load (TMDL). Under this plan (CVRWQCB 2006), the board put in place a number of new rules and requirements. One of these stated that new discharge permits (or WDRs) for runoff from fields and orchards draining to Delta Waterways must contain monitoring to meet a number of goals, the most relevant being:

- Determine attainment of the diazinon and chlorpyrifos water quality objectives and Load Allocations (additivity target).
- Determine whether alternatives to diazinon and chlorpyrifos are causing surface water quality impacts.
- Determine whether the discharge causes or contributes to a toxicity impairment due to additive or synergistic effects of multiple pollutants

In addition are nearly identical requirements for agricultural dischargers to the Sacramento and San Joaquin River under those TMDLs, respectively (Daniel McClure, personal communication).

Control Program for Diazinon and Chlorpyrifos

In 2014, the Central Valley Water Board published an additional amendment to the Basin Plan containing a control program for discharges of diazinon and chlorpyrifos (CVRWQCB 2014). The control plan created new pollution control requirements for waterways designated as supporting both warm and cold freshwater habitats. Under these requirements, agricultural, municipal stormwater, and wastewater dischargers in the Sac -SJR basins below major reservoirs are required to monitor in order to:

- Determine compliance with established water quality objectives applicable to diazinon and/or chlorpyrifos.

- Determine whether alternatives to diazinon and/or chlorpyrifos are being discharged at concentrations which have the potential to cause or contribute to exceedances of applicable water quality objectives.

In addition, agricultural dischargers are also required to monitor water quality in order to:

- Determine whether the discharge causes or contributes to a toxicity impairment due to additive or synergistic effects of multiple pollutants

Pyrethroids Basin Plan Amendment

In 2017, the regional board determined that more than a dozen waterways are impaired due to elevated concentrations of pyrethroid pesticides under Clean Water Act section 303(d). In response, the regional board adopted a Basin Plan Amendment (CVRWQCB 2017) which includes a pyrethroid pesticide control program for the Sacramento and San Joaquin River Basins. This Basin Plan Amendment was adopted by the regional board in June 2017 and it is expected to be fully approved by Stater Water Board, the Office of Administrative Law, and EPA by the end of 2018.

The amendment contains requirements for monitoring of pyrethroids, pyrethroid alternatives, and aquatic toxicity to the invertebrate *Hyalella* in discharges and/or receiving water in order to:

- Determine If the pyrethroid concentration goals are being attained through monitoring pyrethroids either the discharge (POTWs) or discharge or receiving water (MS4s and Ag dischargers)
- Determine whether pyrethroid pesticides are causing or contributing to exceedances of the narrative water quality objective for toxicity – through toxicity testing with Hyalella in water column of receiving waters (POTWs) or receiving waters water column and bed sediments (Ag and MS4s)

This monitoring must be completed two years from the effective date of the Basin Plan Amendment (BPA), expected December 2018. In the long term after that two-year period, dischargers will also be required to monitor for alternative insecticides that could be having water quality impacts.

Assessment Questions Addresssed

Table 5.1 shows the Delta RMP Management and Assessment Questions that the study of pesticides and toxicity is designed to help answer. The table also shows the objectives of the project and examples of how the information collected by the project can be used by water managers and water quality regulators.

Table 5.1 Delta RMP management and assessment questions relevant to pesticides and toxicity monitoring.

Relevant Management and Assessment Questions	Study Objectives	Example Information Application
Management Question Is water quality currently, or trending towards adversely affecting beneficial uses of the Delta? **Assessment Questions** S&T 1 - To what extent do current use pesticides contribute to observed toxicity in the Delta? S&T 1.1 - If samples are toxic, do detected pesticides explain the toxicity? S&T 1.2 - What are the spatial and temporal extent of lethal and sublethal aquatic and sediment toxicity observed in the Delta? S&T 2 - What are the spatial/temporal distributions of concentrations of currently used pesticides identified as possible causes of observed toxicity?	Collect water samples from a variety of locations across Delta subregions and analyze them for a broad suite of current use pesticides and for toxicity to aquatic organisms. Test whether pesticides in ambient water samples exceed aquatic life benchmarks. Test for the co-occurrence of pesticides and observed aquatic toxicity.	The Delta RMP can use this information to determine what percentage of Delta waters exhibit toxicity to aquatic organisms or have concentrations of pesticides that exceed thresholds. State water quality regulators may use this information to help evaluate if waterways should be classified as impaired under section 303(d) of the Clean Water Act. Regulators will be able to evaluate particular stream segments and parameters for signs of impairment, and, after several years of monitoring, may be able to track changes in impairment over time. If certain compounds are found to be having adverse impacts on aquatic environment that prevent the obtainment of beneficial uses, regulators may require the development of a management plan to prevent or mitigate pesticide contamination of waterways, or when warranted, adopt restrictions to further protect surface water from contamination.

5.1.2 Mercury

The Delta Methylmercury TMDL is the embodiment of management decisions for methylmercury in the Delta, establishing goals for cleanup and calling for a variety of control studies and actions. With providing information to support TMDL implementation in mind, the

Mercury Subcommittee carefully considered, refined, and prioritized the assessment questions articulated by the Steering Committee and Technical Advisory Committee for mercury. One priority question for this initial phase of methylmercury monitoring is from the Status and Trends category of the Delta RMP management and assessment questions:

1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?

    A. Do trends over time in methylmercury in sport fish vary among Delta subareas?

Question 1A is a high priority for managers that relates to the TMDL, and is a primary driver of the sampling design for fish monitoring. Annual monitoring of fish mercury is urgently needed to 1) firmly establish a baseline for each Delta subarea and 2) to characterize the degree of interannual variation, which is essential to designing an efficient monitoring program for detection of long-term trends. In addition to addressing status and trends, this monitoring will establish a foundation for effectiveness tracking - another category of the Delta RMP core management questions.

Other priority assessment questions for this initial phase of methylmercury monitoring relate to one of the major control studies called for in the TMDL: an effort to combine modeling, field data, and laboratory studies to evaluate the potential effects of water project operational changes on methylmercury in Delta channels. The Department of Water Resources (DWR) is currently developing two mathematical models (one each for the Delta and Yolo Bypass) that will allow testing of various land and water management scenarios (DiGiorgio et al. 2016).

These models will be useful in addressing the following Delta RMP management questions relating to 1) sources, pathways, loadings, and processes, and 2) forecasting scenarios. The management questions, as defined by the Delta RMP Steering Committee are:

Sources, Pathways, Loadings, and Processes

1. Which sources, pathways, and processes contribute most to observed levels of methylmercury in fish?

    A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)?

    B. How do internal sources and processes influence methylmercury levels in fish in the Delta?

    C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels in fish in the Delta?

Forecasting Scenarios

1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?

The opportunity to inform these models, which are being developed with a considerable investment of funding from the California Department of Water Resources (DWR), makes monitoring to address these questions a near-term priority for the Delta RMP. The water and sediment monitoring included in this monitoring element will provide important data for developing and applying the mercury models.

Another priority question that will be addressed by this monitoring element relates to the analysis of the linkage between the concentration of mercury in water and uptake by fish; this "linkage analysis" is a key element of the technical basis for the TMDL. This question was not articulated in the core management questions and assessment questions established by the Steering Committee, but was nevertheless identified as a priority by the Mercury Subcommittee. The question is:

> Are there key datasets needed to strengthen the technical foundation of contaminant control programs?

Obtaining additional data on methylmercury in water is one of these key datasets.

5.1.3 Nutrients

The information gathered will provide important baseline information to help stakeholders engaged in the Delta Nutrient Research Plan to determine whether nutrient concentrations cause or contribute to water quality problems and to evaluate how nutrient conditions respond to future management actions.

Assessment Questions Addressed

Status and Trends

ST1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?

- ST1.A. Are trends similar or different across subregions of the Delta?
- ST1.B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? Study relates nutrient demand to landscape elements.

Sources, Pathways, Loadings & Processes

SPLP1. Which sources, pathways, and processes contribute most to observed levels of nutrients?

SPLP1.F. What are the types and sources of nutrient sinks within the Delta?

Forecasting Scenarios

FS1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes? Study provides baseline data against which to evaluate change.

The primary objective of the project is to document the spatial variability of nutrients (Question ST1) for the purpose of evaluating longitudinal transformation in nutrient concentrations, forms and ratios in different zones within the Delta (Question ST1.A). The goal is to identify "hot spots" of nutrient transformation and to locate internal sources and sinks for nutrients within the Delta (Question SPLP1.F). The study is expected to provide initial data to begin addressing Questions ST1.B and FS1.

5.2 Beneficial Uses and Water Quality Goals

Two water quality control plans apply to the Sacramento-San Joaquin Delta: the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (CVRWQCB, 2011.) This is frequently referred to as the *Central Valley Basin Plan* or simply, the *Basin Plan*. The *Basin Plan* is the Central Valley Regional Water Quality Control Board's regulatory reference for meeting the state and federal requirements for water quality control established under the federal *Clean Water Act* and California's Porter-Cologne Water Quality Control Act). The *Basin Plan* establishes numeric and narrative objectives for water quality aimed at protecting beneficial uses of water in the Sacramento River and San Joaquin River Basins, including the Sacramento-San Joaquin River Delta (Chapter III: Water Quality Objectives).

The second water quality control plan that applies to the Delta is the *Bay-Delta Water Quality Control Plan* (SWRCB 2006), commonly referred to as the *Bay-Delta Plan*. The State Water Resources Control Board adopted the Bay-Delta Plan to establish water quality objectives for the Bay-Delta Estuary related to flow and water project operations.

Table 5.2 provides an overview of beneficial uses that are relevant to the prioritized assessment questions (Appendix B) of each of the individual monitoring elements.

Table 5.3 summarizes existing numeric water quality criteria and aquatic life benchmarks for target analytes of pesticide monitoring.Table 5.4 lists the regulatory targets for methylmercury that will be used in evaluations of Delta RMP data.

The Central Valley Regional Water Quality Control Board is developing a Nutrient Research Plan to identify research and modeling needed to determine whether further regulation and

management of nutrients will help address water quality problems of low primary productivity, harmful algal blooms, invasive aquatic plants, and low dissolved oxygen. The Regional Board will make a decision about numeric nutrient water quality objectives at some point in the future. However, the Basin Plan currently establishes a narrative objective for biostimulatory substances that applies to nutrients, and there is a numeric water quality objective for dissolved oxygen.

Table 5.2 Beneficial uses associated with Delta RMP monitoring elements.

Beneficial Use	Pesticides	Mercury	Nutrients
Cold Freshwater Habitat (COLD)	X	X	X
Commercial and Sport Fishing (COMM)		X	X
Estuarine Habitat (EST)	X	X	X
Fish Migration (MIGR)	X		X
Municipal and Domestic Water Supply (MUN)			X
Water Contact Recreation (REC1)			X
Noncontact Water Recreation (REC2)			X
Fish Spawning (SPWN)	X		X
Warm Freshwater Habitat (WARM)	X	X	X
Wildlife Habitat (WILD)	X	X	X

Table 5.3 EPA Office of Water (OW) Aquatic Life Ambient Water Quality Criteria, EPA Office of Pesticide Programs (OPP) Aquatic Life Benchmarks[5], and Water Quality Objectives for target analytes of pesticide monitoring (Central Valley Water Board 1998, 2007; EPA 2000, 2015a, 2015b). **All concentrations are in µg/L.**

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Degradates													
Chlorpyrifos OA	—	—	—	—	—	—	—	—	—	—	—	—	—
Dichlorophenyl-3-methyl Urea, 3,4-	—	—	—	—	—	—	—	—	—	—	—	—	—
DDD(p,p')	—	—	—	—	—	—	—	—	—	—	—	—	—
DDE(p,p')	—	—	—	—	—	—	—	—	—	—	—	—	—
Dichloroaniline, 3,4-	—	—	—	—	—	—	—	—	—	—	—	—	—
Dichloroaniline, 3,5-	—	—	—	—	—	—	—	—	—	—	—	—	—
Dichlorophenyl Urea, 3,4-	—	—	—	—	—	—	—	—	—	—	—	—	—
Diazoxon	—	—	—	—	—	—	—	—	—	—	—	—	—
Fipronil Desulfinyl	—	—	—	—	—	—	10	0.59	100	10.3	140	>100	—
Fipronil Desulfinyl Amide	—	—	—	—	—	—	—	—	—	—	—	—	—
Fipronil Sulfide	—	—	—	—	—	—	41.5	6.6	1.065	0.11	140	>100	—
Fipronil Sulfone	—	—	—	—	—	—	12.5	0.67	0.36	0.037	140	>100	—
Malaoxon	—	—	—	—	0.065	0.013	—	—	—	—	—	—	—
Tebupirimfos oxon	—	—	—	—	—	—	—	—	—	—	—	—	—
Fungicides													

[5] EPA. 2015a. Aquatic Life Benchmarks for Pesticide Registration. URL: http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/aquatic-life-benchmarks-pesticide-registration#benchmarks. Accessed on July 8, 2016.

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Acibenzolar-S-methyl	—	—	—	—	—	—	—	—	—	—	—	—	—
Azoxystrobin	—	—	—	—	—	—	235	147	130	44	49	3,400	—
Boscalid	—	—	—	—	—	—	1,350	116	>2,665	790	1340	>3,900	—
Captan	—	—	—	—	—	—	13.1	16.5	4,200	560	320	>12,700	—
Carbendazim	—	—	—	—	—	—	*190*	—	*150*	—	*7700*	—	*75*
Chlorothalonil	—	—	—	—	—	—	5.25	3	1.8	0.6	6.8	630	—
Cyazofamid	—	—	—	—	—	—	>53.5	90.1	>650	<87	—	>1,220	—
Cymoxanil	—	—	—	—	—	—	*29,000*	—	*27,000*	—	*254*	—	*254*
Cyproconazole	—	—	—	—	—	—	—	—	—	—	—	—	—
Cyprodinil	—	—	—	—	—	—	1,205	230	16	8	2,250	—	—
Desthio-Prothioconazole	—	—	—	—	—	—	—	—	—	—	—	—	—
Difenoconazole	—	—	—	—	—	—	405	8.7	385	5.6	98	1,900	—
Dimethomorph	—	—	—	—	—	—	3,100	<341	>5,300	110	—	—	—
Ethaboxam	—	—	—	—	—	—	—	—	—	—	—	—	—
Famoxadone	—	—	—	—	—	—	*11*	—	*12*	—	*22*	—	*5.5*
Fenamidone	—	—	—	—	—	—	370	4.7	24.5	12.5	70	>880	—
Fenarimol	—	—	—	—	—	—	450	180	3,400	113	100	—	—
Fenbuconazole	—	—	—	—	—	—	*1,500*	—	*2,300*	—	*330*	—	*330*
Fenhexamide	—	—	—	—	—	—	670	101	>9,400	1,000	4,820	>2,300	—
Fluazinam	—	—	—	—	—	—	18	0.69	90	68	1.1	—	—
Fludioxonil	—	—	—	—	—	—	235	19	450	<19	70	>1,000	—
Fluopicolide	—	—	—	—	—	—	174.5	151	>850	190	<1.4	>3,200	—
Fluoxastrobin	—	—	—	—	—	—	*435*	—	*480*	—	*350*	—	*217.5*

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Flusilazole	—	—	—	—	—	—	—	—	—	—	—	—	—
Flutolanil	—	—	—	—	—	—	1,250	233	>3,400	530	8,010	8,010	—
Flutriafol	—	—	—	—	—	—	16,500	4,800	33,550	310	460	780	—
Fluxapyroxad	—	—	—	—	—	—	—	—	—	—	—	—	—
Imazalil	—	—	—	—	—	—	*1,480*	—	*3,500*	—	*870*	—	*740*
Ipconazole	—	—	—	—	—	—	765	0.18	850	—	—	—	—
Iprodione	—	—	—	—	—	—	—	260	120	—	>130	>12,640	—
Kresoxim-methyl	—	—	—	—	—	—	95	87	166	55	29.2	>301	—
Mandipropamid	—	—	—	—	—	—	—	220	3,550	—	>2,500	>7,400	—
Metalaxyl	—	—	—	—	—	—	65,000	9,100	14,000	100	140,000	92,000	—
Metconazole	—	—	—	—	—	—	*2,100*	—	*4,200*	—	*1,700*	—	*1,050*
Myclobutanil	—	—	—	—	—	—	1,200	980	5500	—	830	—	—
Paclobutrazol	—	—	—	—	—	—	7,950	49	120	9	40,800	8	—
PCNB	—	—	—	—	—	—	50	13	385	18	—	—	—
Picoxystrobin	—	—	—	—	—	—	32.5	36	12	1	4	210	—
Propiconazole	—	—	—	—	—	—	425	95	650	260	21	4,828	—
Pyraclostrobin	—	—	—	—	—	—	3.1	2.35	7.85	4	1.5	1,720	—
Pyrimethanil	—	—	—	—	—	—	5,050	20	1,500	1,000	1,800	7,800	—
Quinoxyfen	—	—	—	—	—	—	—	—	—	—	—	—	—
Sedaxane	—	—	—	—	—	—	—	—	—	—	—	—	—
Tebuconazole	—	—	—	—	—	—	1,135	12	1,440	120	1,450	151.5	—
Tetraconazole	—	—	—	—	—	—	1,925	300	1315	190	—	310	—
Thiabendazole	—	—	—	—	—	—	280	110	155	42	3,060	2,320	—

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Triadimefon	—	—	—	—	—	—	2,050	41	800	52	17,000	—	—
Triadimenol	—	—	—	—	—	—	—	—	—	—	—	—	—
Trifloxystrobin	—	—	—	—	—	—	7.15	4.3	12.65	2.76	37.1	>1,930	—
Triflumizole	—	—	—	—	—	—	290	33	700	67	140	720	—
Triticonazole	—	—	—	—	—	—	—	—	—	—	—	—	—
Zoxamide	—	—	—	—	—	—	78	3.48	>390	39	10	19	—
Herbicides													
Alachlor	—	—	—	—	—	—	900	187	1,250	110	1.64	2.3	—
Atrazine	—	—	—	—	—	—	2,650	—	360	60	<1	0.001	—
Benfluralin	—	—	—	—	—	—	—	—	—	—	—	—	—
Butralin	—	—	—	—	—	—	—	—	—	—	—	—	—
Butylate	—	—	—	—	—	—	105	—	5,950	—	—	—	—
Clomazone	—	—	—	—	—	—	1,450	350	2,700	2,200	167	30,200	—
Cycloate	—	—	—	—	—	—	2,250	—	1,300	—	—	—	—
Cyhalofop-butyl	—	—	—	—	—	—	*790*	—	*2,700*	—	*960*	—	*395*
Dacthal	—	—	—	—	—	—	15,000	—	13,500	—	>11,000	>11,000	—
Dithiopyr	—	—	—	—	—	—	—	—	—	—	—	—	—
Diuron	—	—	—	—	—	—	200	26.4	80	200	2.4	15	—
EPTC	—	—	—	—	—	—	7,000	—	3,250	800	1,400	5,600	—
Ethalfluralin	—	—	—	—	—	—	16	0.4	30	24	25	—	—
Flufenacet	—	—	—	—	—	—	—	—	—	—	—	—	—
Fluridone	—	—	—	—	—	—	2800	480	680	—	—	—	—
Hexazinone	—	—	—	—	—	—	137,000	17,000	75,800	20,000	7	37.4	—

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Metolachlor	—	—	—	—	—	—	1,600	30	550	1	8	21	—
Molinate	—	—	—	—	—	—	105	390	170	340	220	3,300	—
Napropamide	—	—	—	—	—	—	3,200	1,100	7,150	1,100	3,400	—	—
Novaluron	—	—	—	—	—	—	>490	6.16	0.075	0.03	3,549	>75.4	—
Oryzalin	—	—	—	—	—	—	1,440	220	750	358	42	>15.4	—
Oxadiazon	—	—	—	—	—	—	600	33	1090	33	5.2	41	—
Oxyfluorfen	—	—	—	—	—	—	100	1.3	750	13	1.1	0.33	—
Pebulate	—	—	—	—	—	—	3,150	—	3,315	—	230	1,800	—
Pendimethalin	—	—	—	—	—	—	69	6.3	140	14.5	5.2	12.5	—
Penoxsulam	—	—	—	—	—	—	>51,000	10,200	>49,250	2,950	92	3	—
Prodiamine	—	—	—	—	—	—	>6.5	—	>6.5	1.5	—	—	—
Prometon	—	—	—	—	—	—	6,000	19,700	12,850	3,450	98	—	—
Prometryn	—	—	—	—	—	—	1,455	620	4,850	1,000	1.04	11.9	—
Propanil	—	—	—	—	—	—	1,150	9.1	600	86	16	110	—
Pronamide	—	—	—	—	—	—	36,000	7,700	>2,800	600	>4,000	1,180	—
Simazine	—	—	—	—	—	—	3,200	—	500	—	2.24	140	—
Thiazopyr	—	—	—	—	—	—	*3,400*	—	*6,100*	—	*40*	—	*40*
Thiobencarb	—	—	—	—	—	—	220	21	50.6	1.0	17	770	—
Triallate	—	—	—	—	—	—	600	38	45.5	14	21	2,400	—
Tributhyl Phosphorotrithioate, S,S,S-	—	—	—	—	—	—	122.5	3.5	3.4	1.56	148	1,100	—
Trifluralin	—	—	—	—	—	—	20.5	1.14	280	2.4	7.52	43.5	—
Insecticides													

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Acetamiprid	—	—	—	—	—	—	>50,000	19,200	10.5	2.1	>1,000	>1,000	—
Allethrin	—	—	—	—	—	—	—	—	1.05	—	—	—	—
Bifenthrin	—	—	—	—	—	—	0.075	0.04	0.8	0.013	—	—	—
Carbaryl	—	—	2.1	2.1	2.1	2.1	110	6	0.85	0.5	660	1,500	—
Carbofuran	—	—	—	—	—	—	44	5.7	1.115	0.75	—	—	—
Chlorantraniliprole	—	—	—	—	—	—	>600	110	4.9	4.5	1,800	2,000	—
Chlorpyrifos	0.025	0.015	—	—	0.083	0.041	0.9	0.57	0.05	0.04	140	—	0.025
Clothianidin	—	—	—	—	—	—	>50,750	9,700	11	11	64,000	121,000	—
Coumaphos	—	—	—	—	—	—	140	11.7	0.037	0.0337	—	—	—
Cyantranilipole	—	—	—	—	—	—	>5,000	10,700	10.2	6.56	>10,000	12,100	—
Cyfluthrin, Total	—	—	—	—	—	—	0.034	0.01	0.0125	0.0074	>181	—	—
Cyhalothrin, Total	—	—	—	—	—	—	—	—	—	—	—	—	—
Cypermethrin, Total	—	—	—	—	—	—	0.195	0.14	0.21	0.069	—	—	—
DDT(p,p')	—	—	1.1	0.001	1.1	0.001	—	—	—	—	—	—	—
Deltamethrin	—	—	—	—	—	—	0.29	0.017	0.055	0.0041	—	—	—
Diazinon	0.16	0.1	—	—	0.17	0.17	45	<0.55	0.105	0.17	3700	—	0.16
Dinotefuran	—	—	—	—	—	—	>49,550	>6,360	>484,150	>95300	>97,600	>110,000	—
Esfenvalerate	—	—	—	—	—	—	0.035	0.035	0.025	0.017	—	—	—
Ethofenprox	—	—	—	—	—	—	1.35	23	0.4	0.17	>18.8	>26	—
Fenpropathrin	—	—	—	—	—	—	1.1	0.091	0.265	0.064	—	—	—
Fenpyroximate	—	—	—	—	—	—	0.22	0.11	0.8	0.56	1.9	>190	—
Fenthion	—	—	—	—	—	—	415	7.5	2.6	0.013	400	>2,800	—
Fipronil	—	—	—	—	—	—	41.5	6.6	0.11	0.011	140	>100	—

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Flonicamid	—	—	—	—	—	—	*100,000*	—	*100,000*	—	*3,300*	—	*3,300*
Imidacloprid	—	—	—	—	—	—	>114,500	9,000	0.385	0.01	>10,000	—	—
Indoxacarb	—	—	—	—	—	—	145	150	300	75	>110	>84	—
Malathion	—	—	—	—	—	0.1	16.5	8.6	0.295	0.035	2,400	>9,630	—
Methidathion	—	—	—	—	0.065	0.013	1.1	6.3	1.5	0.66	—	—	—
Methoprene	—	—	—	—	—	—	380	48	165	51	—	—	—
Methoxyfenozide	—	—	—	—	—	—	>2,100	530	25	6.3	>3400	—	—
Parathion, Methyl	—	—	—	—	—	—	925	<10	0.485	0.25	15,000	18,000	—
Pentachloroanisole	—	—	—	—	—	—	28	—	150	—	—	—	—
Permethrin, Total	—	—	—	—	—	—	0.395	0.0515	0.0106	0.0014	68	—	—
Phenothrin	—	—	—	—	—	—	—	—	—	—	—	—	—
Phosmet	—	—	—	—	—	—	35	3.2	1	0.8	—	—	—
Propargite	—	—	—	—	—	—	59	16	37	9	66.2	75,000	—
Pyridaben	—	—	—	—	—	—	—	—	—	—	—	—	—
Resmethrin	—	—	—	—	—	—	0.14	0.35	1.55	—	—	—	—
Tebupirimfos	—	—	—	—	—	—	44.5	130	0.039	0.011	630	8,800	—
Tefluthrin	—	—	—	—	—	—	0.03	0.004	0.035	0.008	—	—	—
Tetradifon	—	—	—	—	—	—	—	—	—	—	—	—	—
Tetramethrin	—	—	—	—	—	—	1.85	—	22.5	—	—	—	—
T-Fluvalinate	—	—	—	—	—	—	—	—	—	—	—	—	—
Thiacloprid	—	—	—	—	—	—	12,600	918	18.9	0.97	45,000	>95,400	—
Thiamethoxam	—	—	—	—	—	—	>50,000	20,000	17.5	—	>97,000	>90,000	—
Tolfenpyrad	—	—	—	—	—	—	—	—	—	—	—	—	—

Pesticide	Water Quality Objectives		Water Quality Objectives		OW Aquatic Life Criteria		OPP Aquatic Life Benchmarks *(italicized: OPP benchmark equivalents, Luo et al. 2013)*						OPP Benchmark Equivalents
	R5 -Delta		CA Toxics Rule				Fish		Invertebrates		Nonvascular plants	Vascular plants	Lowest reported
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Acute	Acute
Plant Growth Regulators													
Flumetralin	—	—	—	—	—	—	—	—	—	—	—	—	—
Synergists													
Piperonyl Butoxide	—	—	—	—	—	—	950	40	255	30	—	—	—

Table 5.4 Water quality objectives for mercury, biostimulatory substances, and dissolved oxygen (Central Valley Regional Water Quality Control Board 2011).

<table>
<tr><th>Constituent</th><th colspan="6">Water Quality Objectives</th></tr>
<tr><td></td><td colspan="6">Central Valley Basin Plan /
Sacramento-San Joaquin Delta and Yolo Bypass waterways</td></tr>
<tr><td rowspan="2">Mercury, Methyl</td><td colspan="3">Muscle tissue of trophic level 4 fish
(mg/kg, wet weight)</td><td colspan="3">Muscle tissue of trophic level 3 fish
(mg/kg, wet weight))</td></tr>
<tr><td colspan="3">0.24[6]</td><td colspan="3">0.08</td></tr>
<tr><td>Biostimulatory substances</td><td colspan="6">Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.</td></tr>
<tr><td rowspan="3">Dissolved Oxygen</td><td colspan="6">Central Valley Basin Plan /</td></tr>
<tr><td colspan="3">Within the legal boundaries of the Delta</td><td colspan="3">Outside the legal boundaries of the Delta</td></tr>
<tr><td colspan="3">Minimum levels
(mg/L)</td><td rowspan="2">Monthly median of the daily mean
(% of saturation)</td><td rowspan="2">95 percentile concentration
(% of saturation)</td><td rowspan="2">Minimum levels
(mg/L)</td></tr>
<tr><td>Sacramento River (below the I Street Bridge) and all Delta waters west of the Antioch Bridge</td><td>San Joaquin River (between Turner Cut and Stockton, 1 September through 30 November)</td><td>All other Delta waters[7]</td></tr>
<tr><td>7.0</td><td>6.0</td><td>5.0</td><td>85</td><td>75</td><td>Waters designated WARM
5.0 mg/l
COLD or SPWN
7.0 mg/l</td></tr>
</table>

[6] Total mercury concentrations are used as a surrogate for methylmercury concentrations in fish tissue.

[7] Except for those bodies of water which are constructed for special purposes and from which fish have been excluded or where the fishery is not important as a beneficial use.

6 Project Tasks Description

6.1 Water Quality Monitoring Overview

The Delta RMP is one of several ongoing water-quality monitoring programs in the Delta. In terms of budgets, it represents less than 10% of all Delta monitoring (Jabusch and Gilbreath, 2009). Therefore, the program seeks to complement existing programs and address gaps in existing monitoring, rather than to comprehensively address every water quality challenge described above.

The Delta RMP collects water quality data to address high-priority management decisions identified in Section 5.1 on page 27. The current Delta RMP monitoring design is predominantly aimed at understanding the status and trends of three classes of pollutants. The Delta RMP will conduct water quality monitoring of (1) pesticides and aquatic toxicity, (2) mercury in water, sediment, and fish tissue, and (3) nutrients (nitrogen and phosphorus) in water.

The pesticides monitoring element includes chemical analyses and toxicity testing. The chemical analyte groups for this monitoring element include several classes of chemicals that are referred to throughout this document as pesticides, including insecticides, herbicides, fungicides, and other compounds in products that are licensed and sold to farmers and residents in California.

Mercury monitoring consists of discrete sample collection and addresses the highest priority information needs related to the implementation of the Methylmercury TMDL.

Nutrient monitoring consists of a high-resolution water quality mapping project to assess spatial variability of nutrients and related water quality constituents in the Delta at the landscape scale. Table 6.1 provides a complete list of target constituents for the current implementation of the Delta RMP.

6.2 Constituents to be Monitored and Reported

Table 6.1 lists the water quality constituents that will be measured by Delta RMP monitoring and special studies.

Table 6.1 Delta RMP target constituents and reporting units.

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
Field parameters – measured by field crews anytime a sample is collected					
Oxygen, Dissolved	Field Measurements	Water	In situ		mg/L
Oxygen, Dissolved	Field Measurements	Water	In situ		% saturation
pH	Field Measurements	Water	In situ		pH

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
Specific Conductivity	Field Measurements	Water	In situ		µS/cm
Temperature	Field Measurements	Water	In situ		°C
Turbidity	Field Measurements	Water	In situ		FNU
Pesticides and Toxicity Monitoring – Toxicity Testing Laboratory Analysis					
Ceriodaphnia dubia (Reproduction)	Water Column Toxicity	Water	grab	n/a	young/original organisms exposed
Ceriodaphnia dubia (Survival)	Water Column Toxicity	Water	grab	n/a	%
Hyalella azteca (Survival)	Water Column Toxicity	Water	grab	n/a	%
Pimephales promelas (Larval biomass)	Water Column Toxicity	Water	grab	n/a	mg/original organisms exposed
Pimephales promelas (Larval survival)	Water Column Toxicity	Water	grab	n/a	%
Selenastrum capricornutum (Growth)	Water Column Toxicity	Water	grab	n/a	cells/mL
Chironomus dilutus (Growth)	Water Column Toxicity	Water	grab	n/a	mg/original organisms exposed
Chironomus dilutus (Survival)	Water Column Toxicity	Water	grab	n/a	%
Pesticides and Toxicity Monitoring – Chemical Analysis Laboratory					
Dissolved Organic Carbon (DOC)	Conventional	Water	Grab	0.23	mg/L
Particulate Organic Carbon (POC)	Conventional	Water	Grab	0.05	mg/L
Total Suspended Solids (TSS)	Conventional	Water	Grab	0.1	mg/L
Copper (dissolved)	Trace Metals	Water	Grab	0.8	µg/L
Suite of 161 Current Use Pesticides – see full list in Table 7.3 on page 81.	Pesticides	Water, Suspended Sediment	Grab		ng/L
Mercury – Fish Sampling					
Total Length	Fish Attributes	Tissue	Individual	n/a	mm
Fork Length	Fish Attributes	Tissue	Individual	n/a	mm

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
Weight	Fish Attributes	Tissue	Individual	n/a	g
Sex	Fish Attributes	Tissue	Individual	n/a	male/female/ unknown
Moisture	Fish Attributes	Tissue	Individual	n/a	%
Total Mercury	Trace Metals	Tissue (fillet muscle)	Individual	0.004	µg/g ww
Mercury - Water Sampling					
Chlorophyll *a*	Conventional	Water	Grab	24	µg/L
Dissolved Organic Carbon (DOC)	Conventional	Water	Grab	0.23	mg/L
Total Suspended Solids (TSS)	Conventional	Water	Grab	n/a	mg/L
TSS (volatile)	Conventional	Water	Grab	n/a	mg/L
Mercury, Methyl, total (unfiltered)	Trace Metals	Water	Grab	0.009	ng/L
Mercury, Methyl, (filtered)	Trace Metals	Water	Grab	0.009	ng/L
Mercury (unfiltered)	Trace Metals	Water	Grab	0.070	ng/L
Mercury (filtered)	Trace Metals	Water	Grab	0.070	ng/L
Mercury - Sediment Sampling					
Total Organic Carbon (TOC)	Conventional	Sediment	Grab	n/a	mg/L
Clay, <0.0039 mm	Sediment Grain Size	Sediment	Grab	n/a	% dw
Silt, 0.0039 mm to <0.0625 mm	Sediment Grain Size	Sediment	Grab	n/a	% dw
Sand, ≥0.0625	Sediment Grain Size	Sediment	Grab	n/a	% dw
Mercury	Trace Metals	Sediment	Grab	0.004	mg/kg dw
Mercury, Methyl	Trace Metals	Sediment	Grab	0.004	mg/kg dw
Nutrients - Water Sampling					
Chlorophyll *a*, total	Laboratory Analysis	Water	Mobile flow-through	0.1	µg/L
Chlorophyll *a* (filtered, > 5 µm)	Laboratory Analysis	Water	Mobile flow-through	0.1	µg/L
Chlorophyll *a*	Field Measurements	Water	Mobile flow-through	0-100	µg/L
Fluorescence of dissolved organic matter (fDOM)	Field Measurements	Water	Mobile flow-through	0.07 - 300	QSE
Nitrate as N	Field Measurements	Water	Mobile flow-through	0.07 - 28	mg/L
Oxygen, Dissolved	Field Measurements	Water	Mobile flow-through	0-20 ±1	mg/L

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
Oxygen, Dissolved	Field Measurements	Water	Mobile flow-through	0-200	% saturation
pH	Field Measurements	Water	Mobile flow-through	4-10	pH
Phycocyanin	Field Measurements	Water	Mobile flow-through	0-100	µg/L
Specific Conductivity	Field Measurements	Water	Mobile flow-through	10-10,000	µS/cm
Temperature	Field Measurements	Water	Mobile flow-through	n/a	°C
Turbidity	Field Measurements	Water	Mobile flow-through	0-999 ±3	FNU
Ammonium as N	Laboratory Analysis	Water	Mobile flow-through	0.01	mg/L
Nitrate and Nitrite as N	Laboratory Analysis	Water	Mobile flow-through	0.02	mg/L
Orthophosphate, dissolved, as P (Soluble reactive phosphorus)	Laboratory Analysis	Water	Mobile flow-through	0.004	mg/L

6.3 Geographical and Temporal Setting

The geographic scope of the Delta RMP encompasses the legal Delta (as defined by Section 12220 of the Water Code), as well as water bodies that directly drain into the Delta, the Yolo Bypass, and Suisun Bay (Figure 6.1). The Delta Primary Zone encompasses approximately 500,000 acres of waterways, levees, and farmed lands, including the Yolo Bypass. Most of Yolo Bypass is located within the Primary Zone. The Secondary Zone includes approximately 250,000 acres that are surrounding the Primary Zone and are subject to increasing urban and suburban development. Suisun Marsh on the northern side of Suisun Bay consists of approximately 110,000 acres of managed wetlands. The southern side of the Suisun Bay shoreline encompasses additional tidal wetlands as well as urban, suburban, and industrial areas.

Water dynamics in the Delta and Suisun Bay are governed by inflows from the Sacramento and San Joaquin watershed, tidal exchange with the Pacific Ocean, and water withdrawals for municipal and agricultural use. The main tributaries are the Sacramento River and the San Joaquin River. Additional tributaries include the Mokelumne River, Cosumnes River, Calaveras River, Bear Creek, Marsh Creek, Cache Creek, Putah Creek, and Ulatis Creek. Flows from the Sacramento River, San Joaquin River, and other tributaries are transported across the Delta through a complex network of rivers, channels, and flooded islands, before entering Suisun Bay or the intakes of the federal and state water projects. Flows in the Delta are highly seasonal and peak in the spring and early summer when snowmelt waters from the upper watersheds arrive.

Important human activity and land use impacts in the Delta and Suisun Bay include the presence of urban and agricultural contaminants throughout the system, habitat loss, and alterations to the amount, duration, direction, and timing of water flows. In addition, more than 200 intentionally or accidentally introduced exotic species are residing in the project area.

6.3.1 Delta Subregions for Pesticides and Toxicity Sampling

For monitoring of pesticides and aquatic toxicity, all samples will be collected from within the legal boundaries of the Delta (Figure 6.1).

Previous efforts by both the Delta RMP and the Central Valley Regional Water Quality Control Board (CVRWQCB) have divided the Delta into roughly similar subregions based on hydrology and management practices. The Delta RMP has divided the Delta into 6 subregions based on the contribution of source waters, as described in the 2018 report *Modeling to Assist Identification of Temporal and Spatial Data Gaps for Nutrient Monitoring* (Jabusch, Trowbridge, Heberger, and Guerin 2018). The rotating basin monitoring design for pesticides and toxicity includes monitoring random points selected within waterways in each of the 6 subregions shown in Figure 6.2. GIS data files (shapefiles) of the subregions are available upon request. Please contact Matthew Heberger, matth@sfei.org.

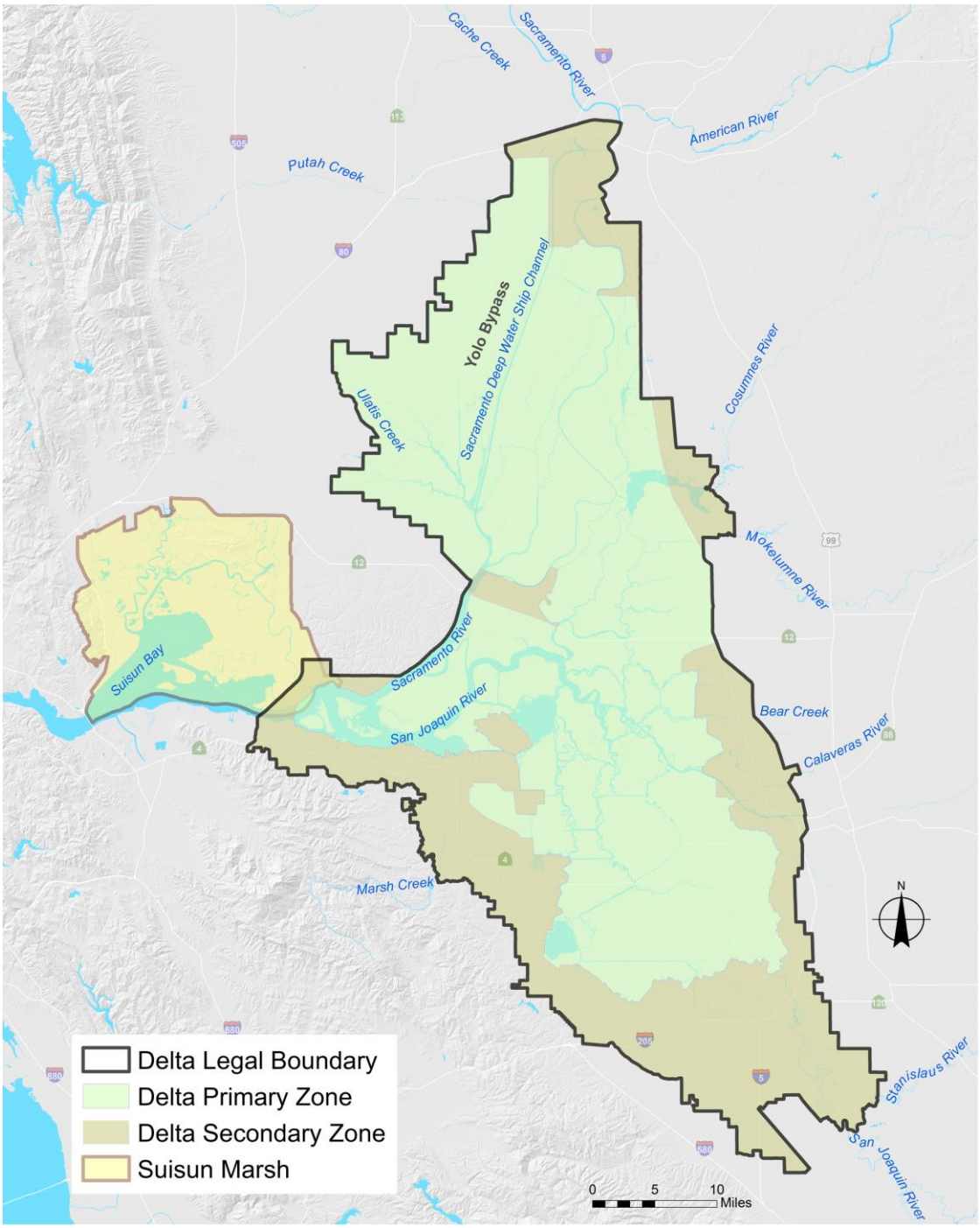

Figure 6.1 The geographic scope of the Delta RMP encompasses the legal Delta (as defined by section 12220 of the Water Code), including water bodies that directly drain into the Delta, Yolo Bypass, and Suisun Bay.

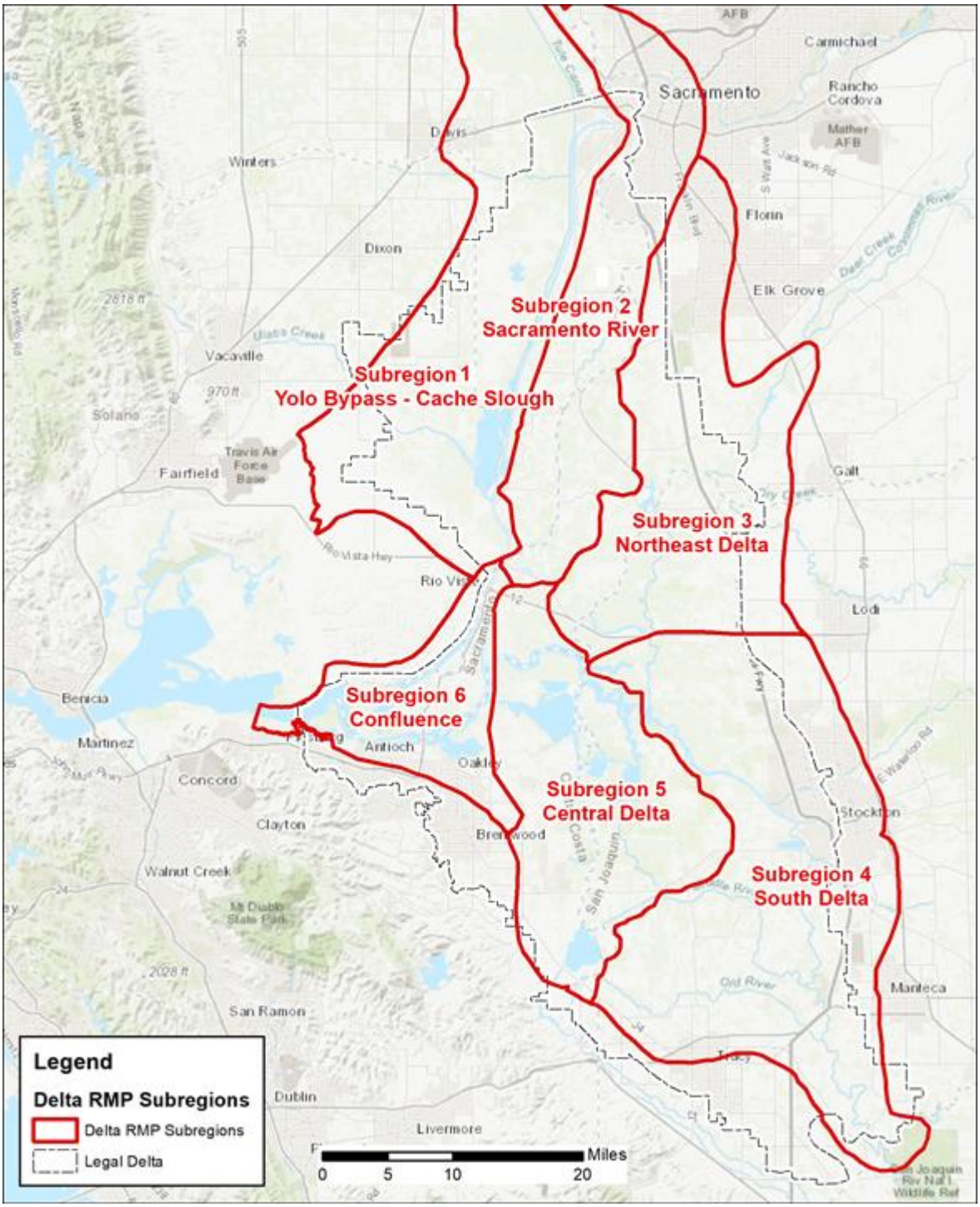

Figure 6.2 Map of Delta RMP Subregions for pesticides and toxicity sampling

6.3.2 Temporal Scope

Delta RMP Status & Trends monitoring is ongoing. Budgets are approved annually by the Steering Committee. Monitoring of mercury in sportfish and water is planned through 2020, in order to provide information to state regulators who are revising water quality control plans for the Central Valley, including the Delta. It is not anticipated that mercury monitoring will end at in 2020, but the frequency of sampling may be decreased, and the focus may shift to monitoring the impacts of wetland restoration projects on the mobilization and transport of mercury.

The monitoring design for pesticides and toxicity is planned for 4 years with year 1 beginning in October 2018 and ending in September 2019.

The surface water samples for pesticide analyses are collected for 6 sampling events during each water year. Samples will be collected over the course of 2 to 3 days during 6 planned monitoring events which represent times of interest such as high agricultural and/or urban irrigation. Other sampling will occur during periods of high flow or following storms when pollutants are flushed from land surfaces into waterways via overland flow and drains. The specific timing for sampling events for pesticides and toxicity has been planned in collaboration with Delta RMP Pesticides Subcommittee and our science advisors and is documented in Section 6.4.3 beginning on page 54.

6.4 Monitoring Design

Delta RMP monitoring includes separate "projects" covering (1) mercury, (2) nutrients, and (3) pesticides and toxicity. The monitoring design for each is described below.

6.4.1 Mercury

The sport fish samples for mercury analyses are collected annually from fixed sites that represent different subareas of the Delta. The surface water and sediment samples for mercury analyses are collected from fixed sites that align with the Delta RMP sport fish monitoring sites. Water samples will be collected 10 times per year.

Planned mercury sampling sites are shown in Figure 6.3 and listed in Table 6.2. The mercury monitoring element includes fish, sediment, and water sampling. The chemical analyte groups for this monitoring element include mercury and methylmercury and ancillary parameters such as chlorophyll *a*, DOC, total suspended solids, and volatile suspended solids.

Table 6.2 Monitoring locations for mercury in water and sportfish.

#	CEDEN Site Code	Site Name	Latitude	Longitude	Annual Sportfish Sampling	Water Sampling (10 events)
1	510ADVLIM	Cache Slough at Liberty Island Mouth	38.24213	-121.68539	●	●
2	544LILPSL	Little Potato Slough	38.09627	-121.49602	●	●
3	544MDRBH4	Middle R @ Borden Hwy (Hwy 4)	37.89083	-121.48833	●	●
4	544ADVLM6	Lower Mokelumne R 6	38.25542	-121.44006	●	●
5	510ST1317	Sacramento R @ Freeport	38.45556	-121.50189	●	●
6	541SJC501	San Joaquin R @ Vernalis/Airport Way	37.67556	-121.26417	●	●
7	207SRD10A	Sacramento River at Mallard Island	38.04288	-121.92011	●	●
8	544DMC020	Delta-Mendota Mendota Canal at Byron-Bethany Road	37.81239	-121.57887	–	●

Note: For a list of valid CEDEN site codes, see:
http://ceden.org/CEDEN_Checker/Checker/DisplayCEDENLookUp.php?List=StationLookUp

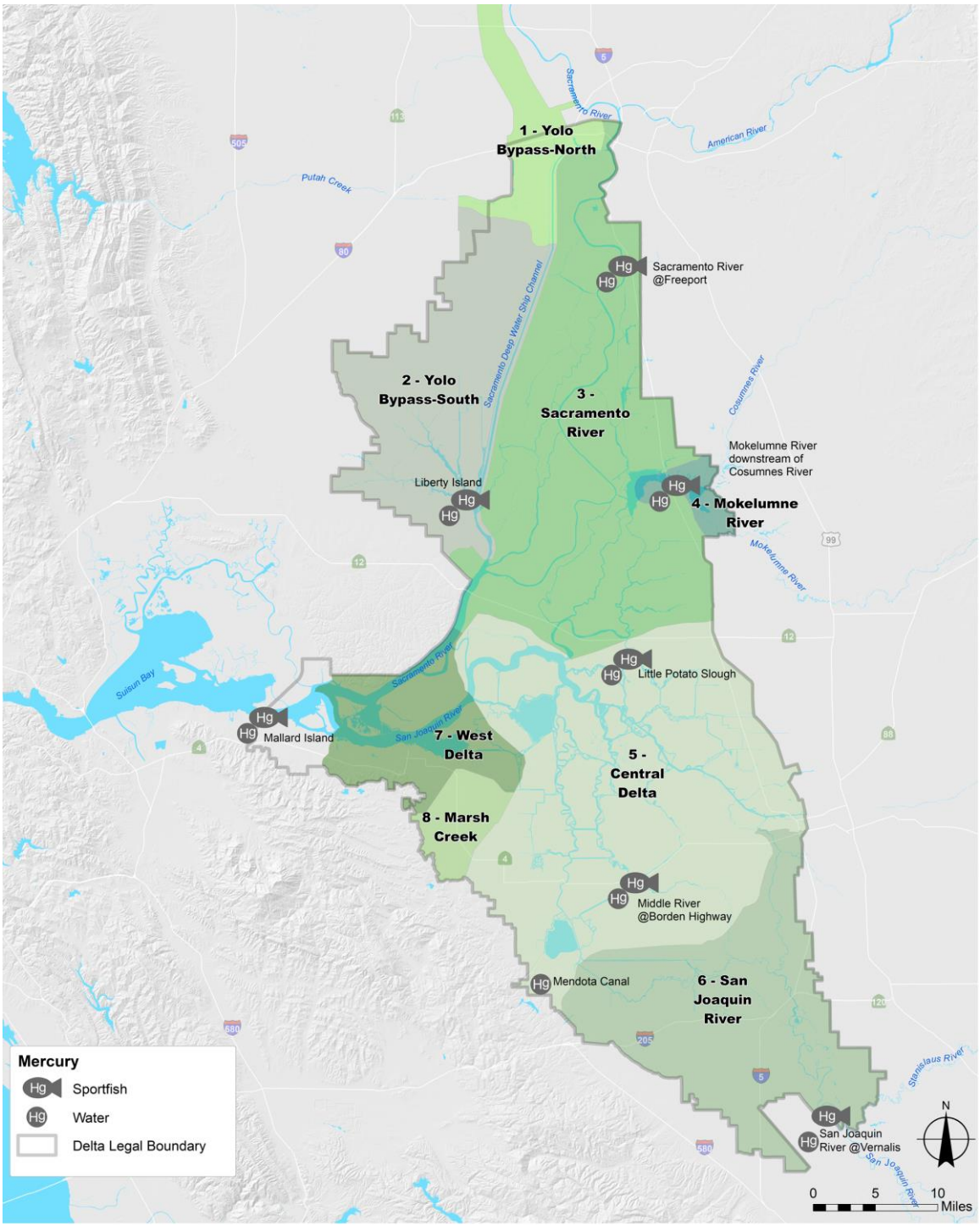

Figure 6.3 Map of mercury monitoring sites.

6.4.2 Nutrients

Three cruise tracks are proposed (Figure 6.4). Planned cruise tracks will be finalized in consultation with the Delta RMP nutrient subcommittee. Tracks are subject to change due to navigational- or safety-related issues. Additional areas may be covered as time permits.

Track A (~75 miles) covers the two major nutrient gradients in the northern Delta: the gradient of declining nitrate and ammonium caused by uptake and loss between the mainstem of the Sacramento River and the Cache Slough complex, and the gradient between the mainstem of the Sacramento River and Suisun Bay.

Track B (~60 miles) starts immediately above the Sacramento Regional Wastewater Plant and generally follows the flowpath of water across the Delta to the Banks Pumping Plant, along Georgiana Slough and Old and Middle Rivers to Clifton Court Forebay.

Track C (~65 miles) covers the gradient of San Joaquin River-derived nutrients into the central part of the Delta. It also covers areas in the central Delta not served by long term monitoring.

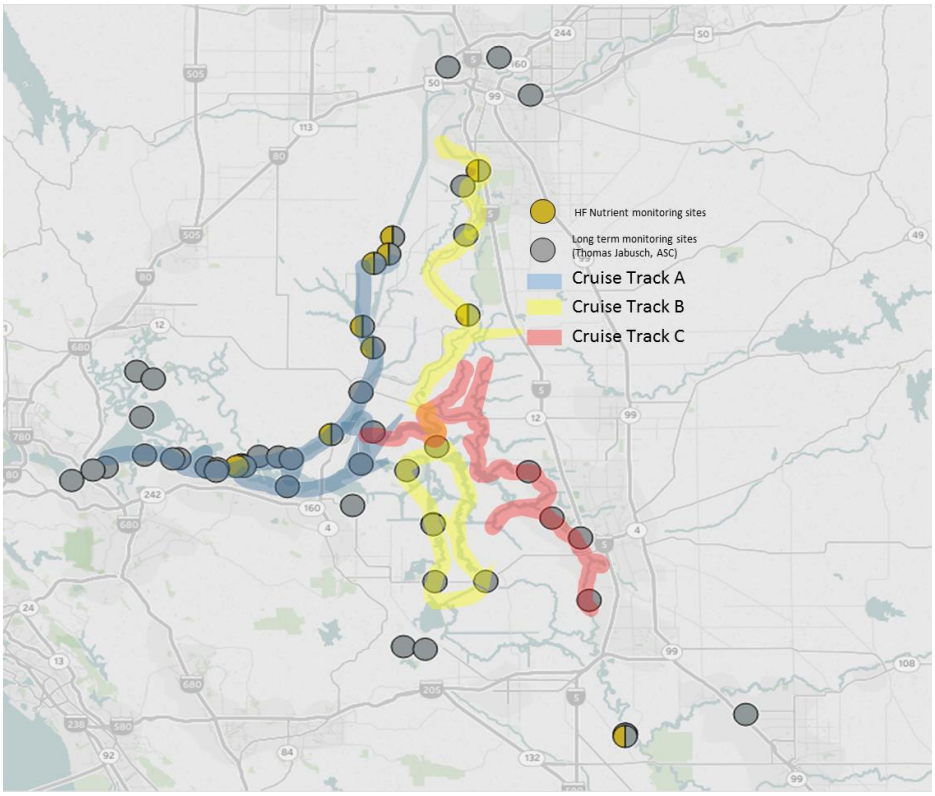

Figure 6.4 Proposed 3-day cruise track for FY17-18 high-resolution nutrient monitoring.

6.4.3 Pesticides and Aquatic Toxicity

A "rotating basin" probabilistic monitoring design was chosen for the purpose of understanding the spatial extent of toxicity and pesticide concentrations (Table 6.3). In this instance, the "basins" are 6 Delta subregions. Under the rotating basin monitoring design, crews shall collect enough samples in each subregion to adequately characterize the mean and variance of pesticide concentrations and toxicity in each subregion. Samples will be collected by boat at randomly-selected locations within each subregion. The locations and timing of sampling are described in more detail below. Samples will be analyzed for a suite of current-use pesticides and for chronic toxicity to 5 organisms as shown in Table 6.1 on page 44. For each

sample, all 5 organisms will be tested. In 2019, staff and the Technical Advisory Committee may consider creating a set of decision rules for which organisms to test based on water quality conditions. For example, invertebrates such as *Ceriodaphnia* and *Hyalella* are known to survive and reproduce well in a relatively narrow range of salinity and hardness. When environmental samples are outside of these ranges, test results are difficult to interpret, and it may be best to save money rather than running these tests.

In addition, the monitoring design calls for continued monitoring 6 times per year at two fixed sites. Both sites, Ulatis Creek at Brown Road and San Joaquin River at Buckley Cove, are locations where aquatic toxicity has been observed by Delta RMP monitoring in the past (see locator map in Figure 6.5). For more information on the first year of Delta RMP pesticides monitoring, see recent reports by the USGS (De Parsia et al. 2018) and SFEI-ASC (Jabusch, Trowbridge, Heberger, Orlando, et al. 2018). Fixed site monitoring allows us to detect temporal trends at these two sites and to analyze of the correlation between observed pesticide concentrations and aquatic toxicity. By sampling at the same location repeatedly, it holds a greater number of factors constant in comparison to the rotating basin component of the monitoring design. This may provide additional opportunities to test for the association between pesticides and toxicity at these locations.

The monitoring design involves collecting 48 ambient surface water samples in each water year from 2019 to 2022.. This monitoring design will result in 24 samples being collected from each of the 6 Delta subregions after 4 years of monitoring. This allows project scientists to make inferences about water quality conditions across the Delta, as well as to detect differences among the subregions. If the monitoring design is continued in the future, scientists may be able to draw inferences about trends or changes over time. However, trend detection is not an emphasis of the rotating basin component of the design.

Table 6.3 Sampling plan for pesticides and toxicity water samples

Number of random sample locations per year in each subregion	24 in first region 12 in second subregion
Subregions evaluated per year	2
Number of repeated sample locations per subregion	0
Number of fixed sites sampling locations	2
Sampling events per year	6
Total samples per year	36 samples at random locations; 12 samples at 2 fixed sites; 48 samples total
Time (years) to collect 24 samples in all subregions covering the Delta	One subregion fully evaluated (n = 24) in any given year. Second subregion will be sampled at half the intensity (n=12) with sampling to be continued over two subsequent years to reach the desired number of samples.

	It will take 4 years in order to obtain the desired 24 samples in each subregion and cover the whole Delta with the desired margin of error.

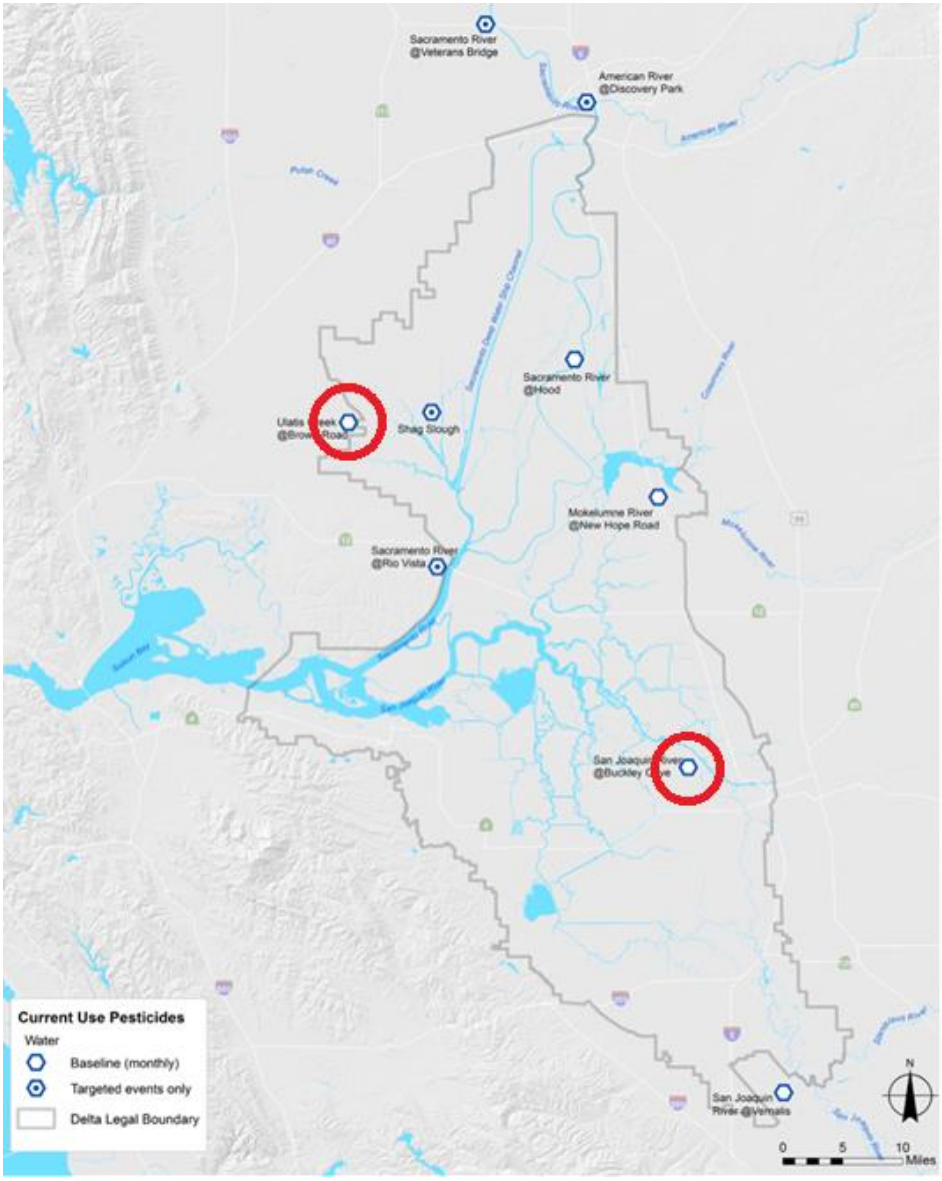

Figure 6.5 Map of Delta RMP integrator sites monitored 2015-2017, highlighting the two fixed stations selected for continued sampling beginning in 2019.

Sampling Locations

Table 6.4 shows basic information about the sampling locations. If a site is inaccessible, field crews will cross this site off the list, and sample the next "oversample" site on the list. field crews should communicate this to the program manager.

Table 6.4 Sampling locations for pesticides and toxicity monitoring

(a) Subregion 1 Sites - Yolo Bypass - Cache Slough

siteID	Planned Sampling Event	Subregion	Latitude	Longitude
Yolo-001	WY2019 Event #1	Yolo Bypass - Cache Slough	38.27952	-121.661
Yolo-002	WY2019 Event #1	Yolo Bypass - Cache Slough	38.26919	-121.69239
Yolo-003	WY2019 Event #1	Yolo Bypass - Cache Slough	38.26105	-121.74786
Yolo-004	WY2019 Event #1	Yolo Bypass - Cache Slough	38.31957	-121.69276
Yolo-005	WY2019 Event #2	Yolo Bypass - Cache Slough	38.25905	-121.66765
Yolo-006	WY2019 Event #2	Yolo Bypass - Cache Slough	38.25214	-121.67558
Yolo-007	WY2019 Event #2	Yolo Bypass - Cache Slough	38.27122	-121.70283
Yolo-008	WY2019 Event #2	Yolo Bypass - Cache Slough	38.2743	-121.67392
Yolo-009	WY2019 Event #3	Yolo Bypass - Cache Slough	38.24957	-121.67482
Yolo-010	WY2019 Event #3	Yolo Bypass - Cache Slough	38.46178	-121.58863
Yolo-011	WY2019 Event #3	Yolo Bypass - Cache Slough	38.30568	-121.65721
Yolo-012	WY2019 Event #3	Yolo Bypass - Cache Slough	38.28241	-121.681
Yolo-013	WY2019 Event #4	Yolo Bypass - Cache Slough	38.2082	-121.66306
Yolo-014	WY2019 Event #4	Yolo Bypass - Cache Slough	38.38195	-121.62601
Yolo-015	WY2019 Event #4	Yolo Bypass - Cache Slough	38.26789	-121.66321
Yolo-016	WY2019 Event #4	Yolo Bypass - Cache Slough	38.25806	-121.7258
Yolo-017	WY2019 Event #5	Yolo Bypass - Cache Slough	38.2833	-121.68577
Yolo-018	WY2019 Event #5	Yolo Bypass - Cache Slough	38.26025	-121.67886
Yolo-019	WY2019 Event #5	Yolo Bypass - Cache Slough	38.43301	-121.60288
Yolo-020	WY2019 Event #5	Yolo Bypass - Cache Slough	38.27881	-121.6778
Yolo-021	WY2019 Event #6	Yolo Bypass - Cache Slough	38.30108	-121.72977
Yolo-022	WY2019 Event #6	Yolo Bypass - Cache Slough	38.31798	-121.65177
Yolo-023	WY2019 Event #6	Yolo Bypass - Cache Slough	38.27899	-121.68779
Yolo-024	WY2019 Event #6	Yolo Bypass - Cache Slough	38.18487	-121.66101
Yolo-025	Yolo Bypass Oversample Point #1	Yolo Bypass - Cache Slough	38.53725	-121.58398
Yolo-026	Yolo Bypass Oversample Point #2	Yolo Bypass - Cache Slough	38.26114	-121.67271
Yolo-027	Yolo Bypass Oversample Point #3	Yolo Bypass - Cache Slough	38.28616	-121.72181
Yolo-028	Yolo Bypass Oversample Point #4	Yolo Bypass - Cache Slough	38.26864	-121.67708
Yolo-029	Yolo Bypass Oversample Point #5	Yolo Bypass - Cache Slough	38.26053	-121.68851
Yolo-030	Yolo Bypass Oversample Point #6	Yolo Bypass - Cache Slough	38.411	-121.6164
Yolo-031	Yolo Bypass Oversample Point #7	Yolo Bypass - Cache Slough	38.288	-121.68209
Yolo-032	Yolo Bypass Oversample Point #8	Yolo Bypass - Cache Slough	38.2411	-121.68302
Yolo-033	Yolo Bypass Oversample Point #9	Yolo Bypass - Cache Slough	38.37009	-121.63221
Yolo-034	Yolo Bypass Oversample Point #10	Yolo Bypass - Cache Slough	38.23202	-121.67517

(b) Subregion 2 Sites - Sacramento River

siteID	Planned Sampling Event	Subregion	Latitude	Longitude
Sacr-001	WY2019 Event #1	Sacramento River	38.16498	-121.62099
Sacr-002	WY2019 Event #1	Sacramento River	38.26207	-121.65129
Sacr-003	WY2019 Event #2	Sacramento River	38.23917	-121.52149
Sacr-004	WY2019 Event #2	Sacramento River	38.37058	-121.55289
Sacr-005	WY2019 Event #3	Sacramento River	38.18899	-121.64127
Sacr-006	WY2019 Event #3	Sacramento River	38.24024	-121.60198
Sacr-007	WY2019 Event #4	Sacramento River	38.47372	-121.52027
Sacr-008	WY2019 Event #4	Sacramento River	38.19473	-121.61907
Sacr-009	WY2019 Event #5	Sacramento River	38.31436	-121.57723
Sacr-010	WY2019 Event #5	Sacramento River	38.45881	-121.5024
Sacr-011	WY2019 Event #6	Sacramento River	38.51454	-121.54563
Sacr-012	WY2019 Event #6	Sacramento River	38.19272	-121.56752
Sacr-013	WY2020 Event #1	Sacramento River	38.33821	-121.5653
Sacr-014	WY2020 Event #1	Sacramento River	38.3777	-121.54217
Sacr-015	WY2020 Event #2	Sacramento River	38.53481	-121.51925
Sacr-016	WY2020 Event #2	Sacramento River	38.17289	-121.64852
Sacr-017	WY2020 Event #3	Sacramento River	38.27415	-121.58859
Sacr-018	WY2020 Event #3	Sacramento River	38.23966	-121.53999
Sacr-019	WY2020 Event #4	Sacramento River	38.57538	-121.51169
Sacr-020	WY2020 Event #4	Sacramento River	38.1846	-121.64806
Sacr-021	WY2020 Event #5	Sacramento River	38.31035	-121.59847
Sacr-022	WY2020 Event #5	Sacramento River	38.41424	-121.52147
Sacr-023	WY2020 Event #6	Sacramento River	38.49416	-121.55587
Sacr-024	WY2020 Event #6	Sacramento River	38.2297	-121.60339
Sac-025	Sac. R. Oversample Point #1	Sacramento River	38.294	-121.58244
Sac-026	Sac. R. Oversample Point #2	Sacramento River	38.34605	-121.54344
Sac-027	Sac. R. Oversample Point #3	Sacramento River	38.47041	-121.50671
Sac-028	Sac. R. Oversample Point #4	Sacramento River	38.22488	-121.55672
Sac-029	Sac. R. Oversample Point #5	Sacramento River	38.33216	-121.58293
Sac-030	Sac. R. Oversample Point #6	Sacramento River	38.39327	-121.51421
Sac-031	Sac. R. Oversample Point #7	Sacramento River	38.56492	-121.52079
Sac-032	Sac. R. Oversample Point #8	Sacramento River	38.16693	-121.62877
Sac-033	Sac. R. Oversample Point #9	Sacramento River	38.24861	-121.60203
Sac-034	Sac. R. Oversample Point #10	Sacramento River	38.43376	-121.53173

These sampling points were created by performing 5 GRTS draws using the R software. The project team selected draw #3, which looked the most "reasonable;" with points reasonably spaced, and no samples appearing too close to one another. Further, it included sample points

in waterways that our technical advisors deemed important such as Discovery Bay, Miner Slough, Steamboat Slough, and the Stairstep.

Before sampling, the field crew chief will inspect each point against aerial photos, and make sure it can be safely reached by boat. If in doubt, the field crew should reject the site and choose the next site on the "oversample" list.

The order of sampling the sites during each sampling event does matter. Field crews should aim to collect all samples in one day, or on two consecutive days, to minimize the hold times and to ensure that the toxicity tests can all be initiated in a single batch. The field crew may sample sites in the order that is most efficient in terms of time, fuel, and other logistical factors.

If the field crew determines that a sampling site is inaccessible or unsafe, a sample should be taken within 100 meters if possible and only if there is not some obvious change in the environment, such as moving downstream of an outfall, a change in water clarity, etc. If not possible to sample within 100 m, the crew should choose the next site on the "oversample" list shown above in Table 6.4.

The monitoring design calls for sampling in 2 subregions each year. Sampling shall begin in regions 1 and 2 in Water Year 2019: (1) Yolo Bypass-Cache Slough, and (2) Sacramento River. Afterwards, sampling will be done in 2 subregions in each year.

As described above, in Water Year 2019, field crews will collect a total of 24 samples in the first subregion, and 12 samples in the second subregion. In other words, the second subregions will be sampled at "half intensity," with sampling split across two consecutive years. After four years, crews will have collected the desired number of samples (n = 24) in each of the 6 subregions. The detailed plan for how many samples to collect in each region is outlined in Table 6.5 below.

Table 6.5 Sampling schedule for random samples in the six Delta subregions

		Number of Random Samples Planned in Water Year				
Subregion Number	**Subregion Name**	**2019**	**2020**	**2021**	**2022**	**Total**
1	Yolo Bypass - Cache Slough	24				**24**
2	Sacramento River	12	12			**24**
3	Northeast Delta		24			**24**
4	South Delta			24		**24**
5	Central Delta			12	12	**24**
6	Confluence				24	**24**
	Total	**36**	**36**	**36**	**36**	**144**

In years which call for collecting 12 samples in a subregion, crews will collect 2 samples during each of the 6 sampling events described in the following section.

Field crews will collect one-sixth of the total samples during each event. For subregions being sampled at full intensity, 4 samples will be collected during each event. For subregions being sampled at half intensity, 2 samples will be collected during each event. The number of samples collected during each event is detailed below in Table 6.6. This table shows the number of regular environmental samples of ambient water to be collected. In addition, field crews should collect field blanks and field duplicate samples at a rate of 1 per 20 samples, as prescribed in Table 14.2. As the study design calls for 48 samples per year, this translates to 3 field duplicates collected during 6 events. The suggested schedule for field duplicates is as follows:

- 1 at a GRTS site during Event 1
- 1 at San Joaquin River at Buckley Cove during sampling Event 3
- 1 at Ulatis Creek during sampling event 5.

Table 6.6 Schedule for ambient water samples to be collected in Water Year 2019 for pesticides and toxicity analysis.

	GRTS Sites in Subregion 1	GRTS Sites in Subregion 2	Fixed Site 1: San Joaquin River at Buckley Cove	Fixed Site 2: Ulatis Crek at Brown's Road	Total
Event 1	4	2	1	1	8
Event 2	4	2	1	1	8
Event 3	4	2	1	1	8
Event 4	4	2	1	1	8
Event 5	4	2	1	1	8
Event 6	4	2	1	1	8
Total	**24**	**12**	**6**	**6**	**48**

Adaptive management of the monitoring design is an important component of Delta RMP monitoring. While a 4-year plan is described here, to date, the Delta RMP Steering Committee has only allocated funding for Water Year 2019. Changes to the schedule described here may be made based on budgets, evolving priorities, or lessons learned from our sampling and data analysis. Changes may be made by the program manager, in consultation with the Pesticides Subcommittee. Major changes shall be subject to review by the Technical Advisory Committee and approval by the Steering Committee. Significant changes shall be documented as an amendment to this document.

Sampling Events

Sampling for pesticides and aquatic toxicity will be conducted over 6 events during the water year, designed to capture a range of hydrologic conditions and periods of the agricultural calendar. Among the 6 planned events, 3 are for storm sampling, and 3 for dry weather / irrigation season. It is necessary to space sampling events by at least 2 weeks so the labs can process all the samples from the previous round.

Planned timing of sampling events is shown in Table 6.7 on the following page. Samples will be taken on the ebb tide, if possible.

Table 6.7 Planned sampling events for pesticides and toxicity monitoring, storm triggers, and criteria.

Event	Event Type	Sampling Triggers	Criteria	Notes
First Flush	Storm Sampling	Guidance plots at appropriate discharge sites or recorded discharge at upstream flow stations show an approximately 2-3X increase in flows. Timing of actual sampling must take streamflow peak travel time into consideration.	First runoff event in response to Central Valley rainfall after Oct 1st that meets the trigger.	
Second Winter Storm	Storm Sampling	Guidance plots at appropriate discharge sites or recorded discharge at upstream flow stations show an approximately 2-3X increase in flows. Timing of actual sampling must take streamflow peak travel time into consideration.	Minimum of 2 weeks since last event (time for lab to complete previous tests)	Reservoir releases for flood control may mask storm runoff signal, need to watch Valley rainfall rates and totals.
Third Winter Storm or Spring Snowmelt runoff prior to irrigation	Storm Sampling/winter runoff	Guidance plots at appropriate discharge sites or recorded discharge at upstream flow stations show an approximately 2-3X increase in flows. Timing of actual sampling must take streamflow peak travel time into consideration.	Minimum of 2 weeks since last event (time for lab to complete previous tests)	If a 3rd significant storm does not materialize. Sample by the end of April during snowmelt period and prior to irrigation season.
Spring	Irrigation/Baseflow	None	Approximately May-June but at least 30 days following last major rainfall/runoff event in Valley, to give time for drying of soils and initiation of irrigation season.	Timing of this sampling event is variable based on winter/spring rainfall timing and initiation of irrigation.
Summer	Irrigation/Baseflow	None	Approximately mid July	
Fall	Irrigation/Baseflow	None	Approximately September - October	Timing of this sampling event may be adjusted in Water Year 2020 to avoid missing samples due to the expiration of SWAMP contract with AHPL in March 2020.

6.5 Constraints

There is a constraint related to the timing of sampling for pesticides and toxicity due to the operations of the toxicity testing lab. The monitoring design calls for collecting "split" samples at the same place and time, and sending a portion of the sample for pesticides chemical analysis, and the other portion to the toxicity testing lab. This sample design is intended to determine whether there is a relationship between pesticides in Delta waterways and harm to aquatic ecosystems. Because of the way the lab is staffed and operated, field crews can only collect samples on Monday through Thursday because of timing of getting test organisms into the lab and getting the tests set up.

The ability to measure some of the target compounds at the ultra-trace levels found in the ambient environment may be constrained by the detection limits routinely achievable by analytical laboratories. Target detection limits in this document represent those achieved by laboratories contracted by the Delta RMP or levels needed to obtain quantitative measurements of ambient concentrations in a majority of samples.

Another constraint is that discrete samples represent only a moment in time and may therefore not always represent conditions during other time periods.

6.6 Evaluation of Monitoring Data

Data analyses and interpretation in the Delta RMP provide answers to the assessment questions, and ultimately, the management questions (see Section 5.1).

Program participants develop the interpretation collectively in a science-based and collaborative process. With oversight by the TAC, program staff and contracted independent scientists conduct the relevant analyses by evaluating the data against the specific monitoring questions (Section 5.1) and, for mercury, the benchmarks stated in Table 7.4.

6.6.1 Mercury

The specific monitoring questions for mercury are listed in Section 5.1.2 on page 30. Mercury concentrations will be evaluated for trends in time series and compared to the fish tissue TMDL target listed in Table 5.4. Water concentrations for total methylmercury will be compared to the TMDL goal listed in Table 5.4. Water concentrations for total and filtered methylmercury and mercury will be compared to past data and to concentrations in fish and sediment, in order to update the linkage analysis. Sediment data for mercury and methylmercury will be compared to past data, and to water and fish data in order to update the linkage analysis.

6.6.2 Nutrients

The high-resolution nutrient monitoring study is designed to document the spatial variability of nutrients for the purpose of evaluating longitudinal transformation in nutrient concentrations,

forms, and ratios in different zones within the Delta. Analysis of spatial variation will evaluate statistically significant variations in nutrient concentrations that exceed uncertainty. Descriptive statistics and multivariate classification of both the laboratory and in situ optical measurements will be obtained using parallel factor analysis (PARAFAC), principle component analysis (PCA), and/or discriminant analysis (DA) to obtain significant variation over spatial and temporal scales. The goal is to identify "hot spots" of nutrient transformation and to locate internal sources and sinks for nutrients within the Delta.

6.6.3 Pesticides and Aquatic Toxicity

A better understanding of the effects of contaminants in the apparent decline of Delta ecosystems is a priority for regulators and stakeholders. Pesticide use in the Delta and Central Valley generally is one of the potential drivers of these effects. One of the goals of toxicity testing is to determine whether Delta waterways contain toxic substances in toxic amounts that are impairing the attainment of beneficial uses such as fish and wildlife habitat or municipal water supply.

The overall objectives of the Delta Regional Monitoring Program's (Delta RMP's) Current Use Pesticide (CUP) monitoring program are to collect ambient surface water samples to answer the program's Management and Assessment Questions (Table 5.1). The management and assessment questions are broad and the Delta is large, so addressing them will require a correspondingly large effort over the course of several years. The study design was developed to make the best use of available funding to answer the highest priority Management and Assessment Questions in an initial effort to characterize status and trends of pesticide concentrations and toxicity in the Delta.

6.7 Products and Reporting

Table 6.8 provides a summary of key products of the Delta RMP. Data from Status and Trends monitoring efforts will be made available annually for download via the SFEI-ASC Contaminant Data, Display and Download tool (CD3) (http://cd3.sfei.org), the California Environmental Data Exchange Network (CEDEN), and the California Estuaries web portal. Data will be reported in annual data reports, constituent-specific technical reports (every 2-3 years), and an interpretive main report that will be published in fall 2018 to summarize monitoring results and synthesize the information they provide in the context of the assessment and management questions that provide the framework for the monitoring program.

The Pulse of the Delta/RMP Update will be the main interpretive reporting vehicle for Delta RMP results. The audience of this report will be local, state, and federal decision-makers and the interested public. The data will be interpreted to answer Delta RMP management and assessment questions, based on the most appropriate statistical analyses to be used for evaluating the data in relation to a question, as guided by the TAC. The *Pulse of the Delta* will be

prepared by ASC and external authors that will be identified by spring 2018. Both the TAC and the SC will provide review of the Pulse of the Delta. Prior to release of the Pulse of the Delta, SFEI-ASC will provide basic annual data reports (Annual Monitoring Reports) for review by the TAC and SC.

Technical reports will provide a more in-depth evaluation of monitoring and special study results. Technical reports will facilitate technical review of Delta RMP studies and are targeted to a technical audience. The annual reports and final 3-year technical report for mercury will be prepared by staff from ASC and MPSL. The technical report for the 1-year nutrient study will be prepared by USGS. Technical reports for mercury and nutrients will be submitted first to the Mercury and Nutrient Subcommittees and then to the TAC for technical review. When the technical review is completed, the TAC will make a recommendation to submit the reports to the SC for approval.

Monitoring results will be one of the main decision factors for adaptive changes to the monitoring program. An annual SC planning meeting/workshop will identify adaptations needed to the monitoring program and will be informed by monitoring results. In addition, the TAC will have access to preliminary data through the TAC website and the password-protected data-sharing workspace of the California Estuaries web portal.

Table 6.8 Delta RMP reporting cycle.

Deliverable	Frequency	Release date to the public
Data uploads		
CD3	Annually[1]	March 1
CEDEN	Annually	March 1
California Estuaries web portal	Annually	March 1
Reports		
Annual Monitoring Reports (including QA report)	Annually	March 1
Technical Reports	Variable	Variable
Mercury monitoring report	Every 2-3 years	February 2020 (Final Report for Years 1-3)
Nutrient special study report	Once	Winter 2018/19
Pulse of the Delta	Every 2-3 years	Next edition planned for October 2019

[1]Time period of data for annual reporting: September 1 – October 31.

6.7.1 QA Summary Report

The Project QA officer or designee shall write a report for each dataset outlining the quality of the data. This report highlights any issues that were addressed by the laboratory, project manager, or data management staff. The QA Summary Report includes the following details:

- Lab
- Matrix
- Analyte
- Reporting Issues for Lab to Review
- Formatting Issues for Data Manager to Review
- QA Review:
    - Dataset completeness
    - Overall acceptability
    - MDLs sensitivity
    - Blank sample averages (procedural, field blank)
    - Average precision from replicate field sample
    - Accuracy (using a variety of standard reference materials or matrix spike quality assurance recoveries)
    - Comparison of dissolved and total phases

- Comparison of results to previous year's observations

7 Quality Objectives and Criteria

7.1 Data Quality Objectives

Data Quality Objectives (DQOs) aim to support defensible conclusions that address the management questions and assessment questions in Appendices A and B.

7.1.1 Pesticides

The overall objectives of the Delta RMP's Current Use Pesticide (CUP) monitoring program are to collect ambient surface water samples to answer the Program's Management and Assessment Questions. The management and assessment questions are broad and the Delta is large, so addressing them will require a correspondingly large effort over the course of several years. The study design was developed to make the best use of available funding to answer the highest priority Management and Assessment Questions in an initial effort to characterize status and trends of pesticide concentrations and toxicity in the Delta.

The priority question driving the design for the CUP study is:

ST1. To what extent do current use pesticides contribute to observed toxicity in the Delta?

ST1.1 - If samples are toxic, do detected pesticides explain the toxicity?

ST1.2 - What are the spatial and temporal extent of lethal and sublethal aquatic and sediment toxicity observed in the Delta?

ST2 - What are the spatial/temporal distributions of concentrations of currently used pesticides identified as possible causes of observed toxicity?

Data quality objectives (DQOs) for the pesticides and toxicty monitoring program are shown in Table 7.1. The decision rules in Table 7.1 anticipate that parametric statistical methods will be used. If data are non-normally distributed or regression residuals are non-normal, there may be a need to use nonparametric statistical analysis methods. Non-parametric methods may require larger sample sizes to answer the assessment questions listed in Table 5.1. The tables shows tolerable limits on decision errors (referred to by statisticians as *alpha* and *beta*) based on commonly used assumptions in similar scientific studies. The planned study calls for a statistical significance level (alpha) of 0.05 for a one-tailed hypothesis test. For example, suppose you are testing whether more than 1% of river miles have a pesticide concentration exceeding a threshold. With alpha = 0.05, there is a 5% chance of a false positive with hypothesis testing (incorrectly concluding that concentrations in these river miles exceeds the threshold.) The choice of beta of 0.2 is the probability of a false negative. Statistical power is 1 – beta or 0.8. This

means, for example, that you have a 20% chance of incorrectly concluding that a predicted pesticide concentration does not exceed a threshold.

Water quality thresholds – The simplest and most straightforward way of determining whether a chemical may be causing an adverse impact on a waterway is to compare observed concentrations to a water quality threshold or benchmark. When a threshold has the force of law, it is referred to as a standard, or in California, a water quality objective. However, state and federal regulators have written standards for only a few current use pesticides. For example, the Central Valley Regional Water Quality Control Board has established water quality objectives for chlorpyrifos and diazinon that cover much of the Central Valley including the Delta.[8] For the hundreds of other current use pesticides, there are neither national water quality criteria recommended by the EPA, nor are there state water quality objectives.

Comparing ambient concentrations to benchmarks is a useful first step in the process for interpreting pesticide data and evaluating relative risk. The choice of a threshold is important. If our monitoring shows that concentrations exceed a threshold, the implication is that there is a problem. Yet, the choice of a threshold is a complicated technical question. *Project scientists have not have not explicitly defined thresholds for pesticides,* in part because this work is ongoing, as part of an analysis of pesticides and toxicity data contracted by the Delta RMP to the firm Deltares.

Options for setting thresholds include aquatic life (AL) benchmarks published by the US EPA Office of Pesticide Programs (OPP). OPP benchmarks were developed by the EPA for use in the agency's risk assessments conducted as part of the decision-making process for pesticide registration. The OPP benchmark values are based on the most sensitive species tested within taxonomic groups (fish, invertebrates, vascular and non-vascular plants). They represent the lowest toxicity values available from peer-reviewed data with transparent data quality standards. OPP benchmarks may or may not be useful for interpreting Delta RMP toxicity data. However, these thresholds are broadly relevant to protecting aquatic life. It has also been suggested by TAC members that it may be appropriate to divide OPP aquatic life benchmarks by a safety factor of 5 or 10. This would in line with the precautionary principle, and consistent with the CVRWQCB's Basin Plan, which states that standards will be based on the lowest LC50 divided by 10.[9]

---

[8] See *Amendments to the 1994 Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Central Valley Regional Water Quality Control Board, 2016), Table III-2A, Specific Pesticide Objectives, on page III-6.01. Chronic toxicity is based on the average concentration over a 4-day period.

[9] See Amendments to the 1994 Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (2016), page IV-35: "Where valid testing has developed 96 hour LC50 values for aquatic organisms (the concentration that kills one half of the test organisms in 96 hours), the Board will consider one tenth of this value for the most sensitive species tested as the upper limit (daily maximum) for the protection of aquatic life. Other available technical information on the pesticide (such as Lowest Observed Effect Concentrations and No Observed Effect Levels), the water bodies and the organisms involved will be evaluated to determine if lower concentrations are required to meet the narrative objectives."

Handling of non-detects – In the first two years of pesticide monitoring by the Delta RMP, many of the pesticide chemistry results were non-detects. Statistical methods should be chosen carefully for handling "censored data" (Helsel 2010). Common methods used in the past, such as substitution of zero or one-half the detection limit for non-detects, are known to introduce bias in data analyses. One of our science advisors has recommended the use of the "Nondetects and Data Analysis (NADA)" package in R created by D. Helsel (USGS). Staff anticipate that useful guidance will also be developed as a part of the Delta RMP-funded interpretive report underway by Deltares. The Delta RMP TAC will continue to evaluate non-detect analysis options and provide guidance for future use of non-detect data in interpretative reports and annual summaries. All non-detects will be coded in CEDEN as less than the MDL.

Table 7.1 Analytic approach, decision rule, and data quality objectives

(a) Spatial extent of pesticide, toxicity occurrence

Questions to Answer with Delta RMP Pesticide Data	Analytic Approach	Decision Rule	Data Quality Objectives	Power Analysis
Spatial extent of pesticide, toxicity occurrence For what percent of the subregion was aquatic toxicity and co-occurrence of pesticides greater than risk-based thresholds observed? Over what percentage of the subregion does a pesticide concentration exceed a threshold? Secondary objective that can be evaluated qualitatively: Identify spatial patterns in aquatic toxicity and pesticide concentrations within the subregion to inform decisions about sensitive habitats, sources, and strata for future designs.	**Metrics for toxicity**: 1. Binary variable (0/1, or True/False) indicating whether significant toxicity was observed (stratified by species, and possibly by endpoint) 2. Continuous variable - Percent effect observed for individual toxicity tests: reduction in organism survival, reproduction, or growth compared to control. **Metric for pesticides**: 1. Continuous variable: Observed concentration of individual pesticides, in ng/L 2. Binary variable (0/1 or True/False) Individual pesticide observations exceeding a risk threshold. 3. Frequency with which individual pesticides exceed a threshold. 4. Cumulative frequency of exceedance (for one or all pesticides) 5. Cumulative frequency of exceedance for classes of pesticides grouped by type or mode of action (organophosphate and pyrethroids) Pesticide Toxicity Index*Metric for determining cause of toxicity: outcome of Toxicity Identification Evaluations (TIEs)	Population estimates will be made using open source R software ('spsurvey'). Population estimates are not a statistical test. There is no null hypothesis. The result will be a percent of subregion water area meeting a certain condition such as: -Percent of subregion with statically significant aquatic toxicity -Percent of subregion with pesticide concentrations above risk based thresholds -Percent of subregion with significant toxicity AND pesticide concentrations above risk based thresholds	The sample size for each subregion should be large enough to be able to estimate the percent of subregion's water area with a certain condition with error bars of ±10%. Assume a Type 1 error of <0.05 and a Type 2 error of <0.2 (80% statistical power).	Under a random sampling design, a standard probability distribution known as the binomial distribution can be used to estimate of the upper and lower bounds of confidence intervals. A sample size of n = 24 gives a 90% confidence interval of around ±13%. (This is acceptably close to our objective of ±10%.) More details on the power analysis are available in the study proposal; copies available upon request.

(b) Co-Occurrence of Pesticides and Toxicity

Questions to Answer with Delta RMP Pesticide Data	Analytic Approach	Decision Rule	Data Quality Objectives	Power Analysis
Causes of toxicity Evaluate the co-occurrence of aquatic toxicity and pesticides.	**Metrics for toxicity:** 1. Binary variable (0/1, or True/False) indicating whether significant toxicity was observed (stratified by species, and possibly by endpoint) 2. Continuous variable - Percent effect observed for individual toxicity tests: reduction in organism survival, reproduction, or growth compared to control. **Metrics for pesticides:** 1. Continuous variable: Observed concentration of individual pesticides, in ng/L 2. Binary variable (0/1 or True/False) Individual pesticide observations exceeding a risk threshold. 3. Frequency with which individual pesticides exceed a threshold. 4. Cumulative frequency of exceedance (for one or all pesticides) 5. Cumulative frequency of exceedance for classes of pesticides grouped by type or mode of action (organophosphate and pyrethroids) 6. Pesticide Toxicity Index*	**Statistical Test:** -Logistic Regression -Multivariate linear regression All data from all sites will be pooled for the test if and/or sites to be analyzed individually based on a statistical analysis of their similarity using Generalized Linear Models or Principal Components Analysis. Null hypotheses: Ho: Toxicity is not related to exposure to pesticides. (There is no relationship between pesticide levels and toxicity.) Ha: There exists a relationship between pesticide exposure and the toxicity.	The test should be able to detect a 5% effect** of pesticide exposure with a Type 1 error of <0.1 and a Type 2 error of <0.2 (80% power).	For the site on the San Joaquin River at Buckley Cove, to detect an effect size = 0.03 would require around 60 samples. In this context, an effect size of 0.03 is equivalent to a 3% increase in toxicity to macroinvertebrates for each unit increase in the Pesticide Toxicity Index (PTI). Requires 36 new samples at each site, or 6 years (i.e., collecting 6 samples per year at this fixed location). More details on the power analysis are available in the study proposal; copies available upon request

* The Pesticide Toxicity Index (PTI) is a screening tool to assess potential aquatic toxicity of complex pesticide mixtures by combining measures of pesticide exposure and acute toxicity in an additive toxic-unit model. For more information, see "Pesticide Toxicity Index—A tool for assessing potential toxicity of pesticide mixtures to freshwater aquatic organisms" (Nowell et al. 2014).

** An effect size of 5% means that a unit increase of the PTI would result in a 5% reduction in a toxicity endpoint such as reproduction, survival, or growth. In general, large effect sizes (e.g. 50% reduction in survival) are easier to detect with smaller sample sizes, while small effect sizes (5% reduction in survival) are more difficult to differentiate from random chance and need a much larger number of samples to detect.)

7.1.2 Aquatic Toxicity

7.1.3 Toxicity

For the Delta RMP, the primary goal of toxicity testing is to determine whether pesticides are potentially causing significant aquatic toxicity in the Delta. Toxicity testing is an integrative tool because it evaluates the combined effects from multiple constituents on biota concurrently in site media and provides an environmentally relevant understanding of the potential for beneficial use impairment. Chemical analyses are also important for understanding trends and can be compared with paired sample toxicity test data to identify which pesticides (or other parameter) might be contributing to observed effects.

Toxicity Identification Evaluations (TIEs) are an investigative tool that can be used to identify the cause of toxicity. The primary goal of Delta RMP TIE testing is to determine if pesticides (or degradates, or any of the inert ingredients in the formulated product), are contributing to observed effects.

Appendix I describes the protocol the Delta RMP will follow for deciding whether to initiate a TIE. Toxicity Identification Evaluations are planned for Delta RMP samples where there is $\geq$ 50 percent effect within 96 hours of the test period. TIEs should be initiated within 48 hours of the observation of the TIE trigger being met in the initial sample screening. The primary goal of Delta RMP TIE testing is to identify whether pesticides are causing or contributing to observed toxicity, and if so, which pesticides (or degradates, or any of the inert ingredients in the formulated product) are the drivers. Potential toxicity drivers may be elucidated (via weight of evidence) from the TIE, paired chemistry data, and/or with more advanced TIEs. A secondary goal is to identify other factors (i.e., water quality conditions or other toxicants) contributing to reduced survival, growth, or reproduction.

Table 14.3 and Table 14.4 outline the data quality indicators and MQOs for toxicity testing and water quality measurements associated with the toxicity testing procedures**.** Test Acceptability Criteria shall follow SWAMP guidance (most recent version dated August 22, 2018).[10] Test results will be rejected when test acceptability criteria are not met. However, a sample may be retested and qualified as having exceeded the recommended hold time if the SWAMP contract manager and the AHPL laboratory manager agree on the need for additional testing/retesting.

7.1.4 Mercury

The Delta Methylmercury TMDL uses a tissue-based mercury water quality objective of 0.24 ppm in top predator sport fish to determine impairment within Delta subregions. Monitoring of mercury concentrations in sport fish tissue as an index of mercury impairment in

[10] https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/chronic_freshwater_tox_mqo_082218.pdf

the Delta and as a performance measure for the TMDL was identified by the Delta RMP as a priority data need.

The priority question driving the design for the initial phase of methylmercury monitoring is:

> ST1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?
>
> > ST1.A. Do trends over time in methylmercury in sport fish vary among Delta subareas?
> >
> > ST1.B. Do trends over time in methylmercury in water vary among Delta subareas?

The Data Quality Objectives (DQOs) for measurements of methylmercury and mercury in fish, water, and sediment are the same as those used in mercury studies throughout California, with statewide fish monitoring by the Surface Water Ambient Monitoring Program as a prominent example. The DQOs generally call for indices of accuracy and precision to be within 25% to 30% of expected values. Data of this quality are routinely used for determinations of impairment and trend detection throughout the state and the country. The variance attributable to the analytical process is one of the contributors to the overall variance observed in the data. This variance is therefore accounted for in the power estimates that informed the DQO for detecting a long-term trend. The newly adopted statewide objectives could include data needs with the ability to detect a trend of mercury in fish tissue of 0.040 ppm/year, within representative locations and species in the Delta. This DQO can be refined when additional data are available.

The Delta Methylmercury TMDL describes a statistically significant relationship between the annual average concentration of methylmercury in unfiltered water and average mercury in 350 mm largemouth bass, when data are organized by subarea. The linkage of aqueous methylmercury concentration to fish mercury concentration provides a connection between methylmercury inputs from various in-Delta pathways (e.g., municipal wastewater, municipal stormwater, agricultural drainage, and wetlands) and impairment of beneficial uses. Because of this linkage, the Delta Methylmercury TMDL established an implementation goal of 0.06 ng/L of unfiltered aqueous methylmercury[11][12]. Monitoring of fish mercury and aqueous methylmercury is needed to: better quantify the fish-water linkage that is the foundation of the

[11] For methylmercury, aqueous samples should be analyzed using USEPA method 1630 with a method detection limit of 0.02 ng/L or less. For total recoverable mercury, aqueous samples should be analyzed with a method detection limit of 0.2 ng/l or less.

[12] The preferred method for total mercury is USEPA Method 1631 Revision E. If quality control objectives are not being met (for example, recoveries in matrix spike samples are outside of expected limits) and matrix interferences are suspected as the cause, USEPA Method 245.7 may be used, if detectable concentrations are within the range of the method's calibration and quality control criteria.

TMDL; support development of a mercury model for the Delta; support evaluation of the fish data by providing information on processes and trends; and provide mass balance data for re-evaluation of the Delta Methylmercury TMDL, when it is updated in 2020. Data collected for this project may also be evaluated against the Advisory Tissue Levels developed by the California Office of Environmental health Hazard Assessment (OEHHA; Klasing and Brodberg, 2008).

7.1.5 Nutrients

The priority question driving the design for the nutrient study is:

ST1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?

ST1.A. Are trends similar or different across subregions of the Delta?

The DQO used to address this question is the ability to assess the statistical significance of spatial variation with a defined threshold of $p < 0.001$, based on cumulative uncertainty. To meet the DQO, performance criteria require accuracy of laboratory measurements to within 5% of the measured value at 3 times the method reporting limit and of underway instruments to <2% of the full-scale value. The performance criteria also require that the underway paths are representative of the complexity of the Delta and its tributaries.

Uncertainty due to analytical errors in underway instrumentation is included in the replication inherent in high frequency sampling and reported together with natural variation as standard deviation across averaging periods. Underway instrument performance will be validated against laboratory values and the uncertainty published in the report. Analysis of spatial variation will use this uncertainty to only highlight statistically significant variations that exceed uncertainty. The cumulative uncertainty will be estimated in quadrature or using Monte Carlo simulations over the domain of the uncertainty of the individual measurements.

7.2 Data Quality Indicators

Data Quality Indicators (DQIs) are the quantitative measures and qualitative descriptors used to set limits of acceptable levels of data error. The principal data quality indicators are precision, accuracy/bias, comparability, completeness, and representativeness (SWRCB 2017).

- **Precision** describes how close the agreement is between multiple measurements (SWRCB 2017).
- **Accuracy (Bias)** is the assessment of the closeness of agreement between a measured or determined value and the true value. Bias is the quantitative measure of the difference between those values (NDT 2016).

- **Comparability** expresses the measure of confidence that one dataset can be compared to and combined with another for a decision(s) to be made (US EPA QA/G-5 2002).
- **Completeness** refers to the comparison between the amount of valid data originally planned to be collected, and the actual quantity collected (US EPA QA/G-5 2002).
- **Representativeness** is the degree to which measurements correctly represent the environmental condition, target organism population, and/or watershed to be studied (US EPA QA/G-5 2002).
- **Sensitivity** is the ability of a measurement to detect small quantities and differences in concentration of the measured component.

7.3 Field Quality Control Measurements for Sensors and Sample Collection

7.3.1 Field Measurements

Precision of field measurements is determined by repeated measurement of the same parameter within a single sample, or samples taken in rapid succession (only when conditions are not dynamically variable). The project will address the precision of field measurements by performing replicate measures at the required intervals described in Section 14.1, Field Measurements.

Accuracy of field measurements is established by calibration and tested by periodic measurement of known standards. The project will perform instrument calibration prior to each sampling day or event for user-calibrated instruments (e.g. daily for handheld field meters), or at the manufacturer-specified interval for instruments requiring factory servicing or otherwise incapable of field calibration. All instruments undergo blank and calibration checks as described in Table 14.1. The Flow-through system makes redundant measurements (e.g. two chlorophyll fluorimeters, two fDOM fluorimeters, two thermistors), which allows technical staff to check constituent measurement accuracy throughout the day.

Instruments will also be visually inspected for fouling at the checkpoints and cleaned if necessary. Fouling and drift of instruments may occur due to electrical, optical, and/or communication issues, but redundant measurements can distinguish such issues from environmental variability. Additionally, grab samples are collected for laboratory analysis to ground-truth environmental measurements. The Timberline ammonium analyzer requires a calibration curve at the start and end of each field day. The instrument is intermittently flushed with blank water to monitor drift and check standards are run over the course of the field day.

Completeness of field measurement is evaluated as the percentage of usable measurements out of the total number of measurements desired. The project will ensure that at least 90% of the planned field measurements are collected and are usable. If a lower percentage is achieved for

any sampling event or time period, causes shall be investigated and fixed where possible, through instrument maintenance (e.g. defouling), recalibration, repair, or replacement (with the same or different instrument type) as needed. If completeness targets are not achieved, instrument choice, settings, deployment method, maintenance, and/or other activities shall be adjusted to improve measurement reliability before the next sampling event or measurement period.

Comparability of field measurements will be ensured by using protocols (Section 21.5) and QA standards that are comparable within the project and to similar monitoring projects in the study area.

Representativeness of field measurements will be ensured by utilizing standardized protocols (Section 26.5) and selecting representative monitoring sites and underway paths to support the project management questions (Section 5.1). Conditions that may influence the measurements will be noted in the database and measurements may be re-taken if necessary.

Sensitivity is most commonly defined as the lowest value an instrument or method can measure with reasonable statistical certainty (SWRCB 2017) as well as the ability of the instrument to detect small changes. Where applicable, the desired sensitivity is expressed as a target detection limit (Section 6.2) and resolution of a deployed sensor. For this project, sensors will be used that meet the DQOs.

7.3.2 Field Sample Collection

Precision of the field sample collection will be evaluated by collecting field duplicates/replicates (for water and sediment samples). Duplicate or replicate samples account for variability in the field collection and laboratory analysis combined and are collected at the same time under the same conditions as the original sample. Minimum frequencies and target performance requirements for field duplicates/replicates are described in Table 14.2.

Accuracy. In the field, bias of field sample results can be introduced by contamination that occurs during field sample collection or by matrix interference. Field blanks (for water samples) account for all of the sources of contamination that might be introduced to a sample as well as those due to the immediate field environment, such as possible contamination sources in container and equipment preparation, transport, handling, and sampling methodology. Field blanks are generated under actual field conditions and are subjected to the same aspects of sample collection, field processing, preservation, transport, and laboratory handling as the environmental samples.

Travel/bottle blanks (for water samples) account for contaminants introduced during the transport process between the laboratory and field site, in addition to any contamination from the source solution and container. Equipment blanks (for water samples) account for contamination introduced by the field sampling equipment in addition to the above sources.

Neither Travel/bottle blanks **nor** equipment blanks are planned as part of this project at the present time, as ASC QA staff have found over several years of monitoring experience that these are of little use, as they have never shown any evidence of contamination. The QAO may decide to reinstate these in the future, for example when an established procedure is changed or when contamination problems are identified.

Field duplicates and field blanks will be obtained for each sampling event. Minimum frequencies and target performance requirements for field blanks, travel/bottle blanks, and equipment blanks are described in Table 14.2.

When required, field crew will also collect matrix samples as described in Section 14.1 Field Measurements on page 123.

7.4 Laboratory Quality Control Measurements

The discussion in this section reviews the measurements and procedures expected to demonstrate the quality of reported data. Table 7.2 provides an overview of quality control (QC) sample types and their purpose. The quality assessment process that is used after the data have been collected to evaluate whether the Data Quality Objectives (DQOs) have been satisfied is described and illustrated in Section 22, Data Review, Verification, and Validation.

Table 7.2 Purposes of field and laboratory QC sample types and data quality indicators applicable to the Delta RMP

QC Sample Type	Data Quality Indicator/Purpose
Calibration	Accuracy of measurement (field parameters, laboratory chemical analysis).
Calibration Check	Accuracy of calibration (field parameters, laboratory chemical analysis).
Laboratory Blanks - Method Blanks	Contamination/confirm the absence of analytes introduced in the lab (laboratory chemical analysis).
Laboratory Blanks - Instrument Blanks	Contamination/Assess the presence or absence of instrument contamination (laboratory chemical analysis).
CRM (Reference Material)	Accuracy of measurement (primarily); precision/most robust indicator of measurement accuracy; may also be used to evaluate replicate precision and recovery where average values for field samples are expected (based on historical or literature results) to fall in a non-quantitative range (laboratory chemical analysis).
Laboratory Duplicates - Matrix Spikes (MS)/Matrix Spike Duplicates (MSD)	Accuracy and precision/evaluate the effect of the sample matrix on the recovery of the compound(s) of interest and providing an estimate of analytical precision when measured in duplicate (laboratory chemical analysis).
Laboratory Duplicates - Matrix Duplicates	Precision of intra-laboratory analytical process (laboratory chemical analysis)
Surrogate Spikes	Accuracy of analytical method/assess the efficiency of the extraction method for organic analytes (laboratory chemical analysis).

QC Sample Type	Data Quality Indicator/Purpose
Internal Standards	Accuracy of analytical method/enable optimal quantitation, particularly of complex extracts subject to retention time shifts or instrument interferences relative to the analysis of standards. Internal standards can also be used to detect and correct for problems in the injection port or other parts of the instrument (laboratory chemical analysis).
Field Blanks	Contamination/To check cross- contamination during sample collection, field sample processing, and shipment. Also to check sample containers (laboratory chemical analysis). Field crews will need to include filtration in processing blanks for applicable sample types.
Field Duplicate/Replicate	Precision/Check reproducibility of field procedures. To indicate non-homogeneity. (Field Duplicate: n = 2; Field Replicate: n > 2). This sample is to be collected in the field in tandem with a regular environmental sample. To be preserved, handled and processed as a unique sample. Lab precision is covered below (laboratory chemical analysis).
Instrument Replicates	Precision of instrument (laboratory chemical analysis).
Travel/bottle blanks	Contamination/To account for contaminants introduced during the transport process between the laboratory and field site, in addition to any contamination from the source solution and container (laboratory chemical analysis).
For Aquatic Toxicity Testing Only	
Negative Control (e.g., Laboratory control)	To evaluate test performance, health, and sensitivity of the specific batch of organisms (laboratory toxicity testing).
Negative Control –Tolerance Control Water for Unmanipulated Samples (e.g., Conductivity control)	Evaluates the effects of water quality parameters near the tolerance threshold of the organism (laboratory toxicity testing).
Positive Control (Reference toxicant testing)	Sensitivity, precision and accuracy of toxicity tests performed in the laboratory/Determine the sensitivity of the test organisms over time; assess comparability within and between laboratory test results; identify potential sources of variability, such as test organism health, differences among batches of organisms, changes in laboratory water or food quality, and performance by laboratory analysts (laboratory toxicity testing).

Prior to the initial analyses of samples for the project, each laboratory will demonstrate capability and proficiency for meeting MQOs for the Delta RMP. Performance-based measures for chemical analyses consist of two basic elements: initial demonstration of laboratory capability and on-going demonstration of capability during analysis of project samples. Initial demonstration includes documentation that sample analyses can be performed within the measurement quality objectives and method quality objectives listed in the QAPP (Table 14.2) as well as demonstrate ability to meet the project's required reporting levels. On-going demonstration of capability during analysis of project samples includes routine analyses (e.g., intercomparison studies) that ensure on a continual basis that MQOs and RLs listed in Table 7.3 are met.

7.4.1 Laboratory QC Measurements

Accuracy (Bias) is the assessment of the closeness of agreement between a measured or determined value and the true value. Blank spikes (laboratory control samples or LCSs), matrix spikes/matrix spike duplicates (MSs/MSDs), internal standards, surrogate recoveries, initial calibration, and calibration checks will be employed to ensure accuracy of results.

Sensitivity refers to the capability of a method or instrument to detect a given analyte at a given concentration and reliably quantitate the analyte at that concentration. This project will achieve the desired sensitivity by selecting appropriate analytical methods and the laboratory will demonstrate analytical capability to meet the project DQOs and reporting limits.

Precision is the reproducibility of an analytical measure. Field samples will be utilized to perform laboratory replicates.

Completeness is defined as "a measure of the amount of data collected from a measurement process compared to the amount that was expected to be obtained under the conditions of measurement" (Stanley and Verner 1985). The goal of the Delta RMP is to achieve >90% completeness for all analyses.

Completeness will be quantified as the total number of usable results divided by the total number of site visits, aggregated by all analytes of interest. However, additional factors may be considered on a case-by-case basis.

Contamination. Laboratory method blanks (also called extraction blanks, procedural blanks, or preparation blanks) are used to assess laboratory contamination during all stages of sample preparation and analysis.

Comparability. The Delta RMP adheres to the requirements specified in the SWAMP Quality Assurance Program Plan (QAPrP), for parameters covered by the SWAMP Quality Control and Sample Handling Tables, to facilitate coordination and data integration with other water quality monitoring efforts. Specifically, the Delta RMP adheres to SWAMP requirements for QC and holding times and to California Environmental Data Exchange Network (CEDEN) requirements for data submittal.

Table 7.3 summarizes the reporting limits (RL) and Method detection limits (MDL) for all laboratory measurements. Methods are referred to according to the following codes:

EPA 440 Zimmerman, C. F., Keefe, C. W., Bashe, J. 1997. Method 440.0 Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/00. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309418

EPA 445 US EPA. "Method 445.0 In Vitro Determination of Chlorophyll a and Pheophytin Ain Marine and Freshwater Algae by Fluorescence." US Environmental Protection Agency, 1997. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309417.

EPA 446 Arar, E.J. "Method 446.0: In Vitro Determination of Chlorophylls a, b, c + c and Pheopigments in Marine and Freshwater Algae by Visible Spectrophotometry." Washington, DC: US Environmental Protection Agency, 1997. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309415.

Hladik et al. 2008 Hladik, M.L., Smalling, K.L., and Kuivila, K.M., 2008, A multi-residue method for the analysis of pesticides and pesticide degradates in water using Oasis HLB solid phase extraction and gas chromatography-ion trap mass spectrometry: Bulletin of Environmental Contamination and Toxicology, v. 80, p. 139–144.

NFM-A6 Chapter A6, *Field Measurements* in: Wilde, F. D., D. B. Radtke, Jacob Gibs, and R. T. Iwatsubo. *National Field Manual for the Collection of Water-Quality Data: US Geological Survey Techniques of Water-Resources Investigations*. Handbooks for Water-Resources Investigations, Book 9. Reston, VA: U.S. Geological Survey, 2005. https://water.usgs.gov/owq/FieldManual/.

OFR-92-480 Brenton, R.W., Arnett, T.L. 1993. Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of dissolved organic carbon by UV-promoted persulfate oxidation and infrared spectrometry: U.S. Geological Survey Open-File Report 92-480, 12 p. https://nwql.usgs.gov/rpt.shtml?OFR-92-480

SIR-2012-5206 Hladik, M.L., and Calhoun, D.L., 2012, Analysis of the herbicide diuron, three diuron degradates, and six neonicotinoid insecticides in water—Method details and application to two Georgia streams: U.S. Geological Survey Scientific Investigations Report 2012–5206, 10 p. https://pubs.usgs.gov/sir/2012/5206/pdf/sir20125206.pdf

SM […] Rice, E.W., R.B. Baird, A.D. Eaton, and L.S. Clesceri. *Standard Methods for the Examination of Water and Wastewater*. Water Environmental Federation, American Water Works Association, American Public Health Association, 2005. https://www.standardmethods.org/

The numbers and letters after "SM" refer to the method number in *Standard Methods*. Readers are referred to either the print edition, or individual chapters can be purchased online.

TM-5-C2 Hladik, M.L., Smalling, K.L., and Kuivila, K.M., 2009, Methods of analysis—Determination of pyrethroid insecticides in water and sediment using gas chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods 5–C2, 18 p. https://pubs.usgs.gov/tm/tm5c2/tm5c2.pdf

TM-5-C3 Hladik, M.L., and McWayne, M.M., 2012, Methods of analysis—Determination of pesticides in sediment using gas chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods 5–C3, 18 p. Available at http://pubs.usgs.gov/tm/tm5c3

TM-5-B1 Garbarino, J.R., Kanagy, L.K., Cree, M.E. 2006. Determination of Elements in Natural Water, Biota, Sediment and Soil Samples Using Collision/Reaction Cell Inductively Coupled Plasma-Mass Spectrometry, U.S. Geological Survey Techniques and Methods, 88p. (Book 5, Sec. B, Chap.1). https://pubs.usgs.gov/tm/2006/tm5b1/

TM O-1122-92 R.W. Brenton and T.L. Arnett, 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of dissolved organic carbon by UV-promoted persulfate oxidation and infrared spectrometry: U.S. Geological Survey Open-File Report 92-480. https://pubs.er.usgs.gov/publication/ofr92480

I-2525-89 Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, p. 119 - 124. https://nwql.usgs.gov/rpt.shtml?OFR-93-125

Table 7.3 Summary of reporting limits (RL) and method detection limits (MDL) for Delta RMP constituents.

CAS Registry Number	Constituent	Matrix	Reporting group	RL	MDL	Unit	Analyzing laboratory/ laboratories	Method used
479-61-8	Chlorophyll *a*	Water	Conventional	30	24	µg/L	MPSL (mercury monitoring), USGS (nutrient monitoring)	EPA 445.0 or EPA 446.0
7440-44-0	Dissolved Organic Carbon	Water	Conventional	0.23	0.23	mg/L	MPSL	TM O-1122-92
7440-44-0	Total Organic Carbon	Sediment	Conventional	NA	NA	%	MPSL	EPA 440
479-61-8	Chlorophyll-*a*	Water	Field Parameters	0 - 100	0 - 100	µg/L	USGS	National Field Manual for the Collection for Water-Quality Data, Chapter A6, Field Measure-ments
n/a	fDOM	Water	Field Parameters	0.07 - 300	0.07 - 300	QSE	USGS	
4797-55-8	Nitrate	Water	Field Parameters	0.07 - 28	0.07 - 28	mg N/L	USGS	
11016-15-2	Phycocyanin	Water	Field Parameters	0 - 100	0 - 100	µg/L	USGS	
7782-44-7	Oxygen, Dissolved	Water	Field Parameters	0.5	0.5	mg/L	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	pH	Water	Field Parameters	4-8	4-8	NA	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	Specific Conductivity	Water	Field Parameters	10	10	µS/cm	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	Temperature	Water	Field Parameters	NA	NA	NA	MPSL (mercury monitoring),	

CAS Registry Number	Constituent	Matrix	Reporting group	RL	MDL	Unit	Analyzing laboratory/ laboratories	Method used
							USGS (nutrient monitoring)	
n/a	Turbidity	Water	Field Parameters	1	1	FNU	USGS	
7440-50-8	Copper, dissolved	Water	Trace Metals	0.8	0.8	µg/L	USGS	TM-5-B1
14798-03-9	Ammonium	Water	Nutrients	0.01	0.01	mg N/L	USGS	I-2525-89, I-2522-90
14797-55-8	Nitrate	Water	Nutrients	0.02	0.02	mg N/L	USGS	I-2547-11
n/a	Orthophosphate	Water	Nutrients	0.008	0.008	mg P/L	USGS	I-2601-90, I-2606-89
7439-97-6	Mercury, total	Tissue	Trace Metals	0.012	0.004	µg/g ww	MPSL	EPA 7473
7439-97-6	Mercury, total (unfiltered)	Water	Trace Metals	0.200	0.070	ng/L	MPSL	EPA 1631E
7439-97-6	Mercury, dissolved (filtered)	Water	Trace Metals	0.200	0.070	ng/L	MPSL	EPA 1631E
7439-97-6	Mercury, total	Sediment	Trace Metals	0.012	0.004	mg/kg dw	MPSL	EPA 7473
22967-92-6	Mercury, Methyl	Sediment	Trace Metals	0.013	0.004	µg/kg dw	MPSL	MPSL-110
22967-92-6	Mercury, Methyl, total (unfiltered)	Water	Trace Metals	0.025	0.009	ng/L	MPSL	EPA 1630
22967-92-6	Mercury, Methyl, dissolved (filtered)	Water	Trace Metals	0.025	0.009	ng/L	MPSL	EPA 1630

(b) Suite of 161 current use pesticides analyzed by USGS Organic Chemistry Research Laboratory (OCRL).

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
95-76-1	3,4-Dichloroaniline	Water	Herbicide	3.2	3.2	ng/L	SIR 2012-5206
95-76-1	3,4-Dichloroaniline	Susp. Sed.	Herbicide	8.3	8.3	ng/L	Hladik et al. 2008
626-43-7	3,5-Dichloroaniline	Water	Herbicide	7.6	7.6	ng/L	SIR 2012-5206
626-43-7	3,5-Dichloroaniline	Susp. Sed.	Herbicide	7.6	7.6	ng/L	Hladik et al. 2008
135410-20-7	Acetamiprid	Water	Insecticide	3.3	3.3	ng/L	Hladik et al. 2008
34256-82-1	Acetochlor	Water	Herbicide	1.5	1.5	ng/L	Hladik et al. 2008
34256-82-1	Acetochlor	Susp. Sed.	Herbicide	1.5	1.5	ng/L	TM5-C2
135158-54-2	Acibenzolar-S-methyl	Water	Fungicide	3.0	3.0	ng/L	Hladik et al. 2008
135158-54-2	Acibenzolar-S-methyl	Susp. Sed.	Fungicide	3.0	3.0	ng/L	Hladik et al. 2008
15972-60-8	Alachlor	Water	Herbicide	1.7	1.7	ng/L	Hladik et al. 2008
15972-60-8	Alachlor	Susp. Sed.	Herbicide	1.7	1.7	ng/L	Hladik et al. 2008
584-79-2	Allethrin	Water	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
584-79-2	Allethrin	Susp. Sed.	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
1912-24-9	Atrazine	Water	Herbicide	2.3	2.3	ng/L	TM5-C2
1912-24-9	Atrazine	Susp. Sed.	Herbicide	2.3	2.3	ng/L	Hladik et al. 2008
131860-33-8	Azoxystrobin	Water	Fungicide	3.1	3.1	ng/L	Hladik et al. 2008

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
131860-33-8	Azoxystrobin	Susp. Sed.	Fungicide	3.1	3.1	ng/L	SIR 2012-5206
1861-40-1	Benefin (Benfluralin)	Water	Herbicide	2.0	2.0	ng/L	Hladik et al. 2008
1861-40-1	Benefin (Benfluralin)	Susp. Sed.	Herbicide	2.0	2.0	ng/L	SIR 2012-5206
1072957-71-1	Benzovindiflupyr	Water	Fungicide	3.4	3.4	ng/L	SIR 2012-5206
1072957-71-1	Benzovindiflupyr	Susp. Sed.	Fungicide	3.4	3.4	ng/L	Hladik et al. 2008
82657-04-3	Bifenthrin	Water	Insecticide	0.70	0.70	ng/L	Hladik et al. 2008
82657-04-3	Bifenthrin	Susp. Sed.	Insecticide	0.70	0.70	ng/L	Hladik et al. 2008
188425-85-6	Boscalid	Water	Fungicide	2.8	2.8	ng/L	Hladik et al. 2008
188425-85-6	Boscalid	Susp. Sed.	Fungicide	2.8	2.8	ng/L	Hladik et al. 2008
33629-47-9	Butralin	Water	Herbicide	2.6	2.6	ng/L	SIR 2012-5206
33629-47-9	Butralin	Susp. Sed.	Herbicide	2.6	2.6	ng/L	SIR 2012-5206
133-06-2	Captan	Water	Fungicide	10.2	10.2	ng/L	Hladik et al. 2008
133-06-2	Captan	Susp. Sed.	Fungicide	10.2	10.2	ng/L	TM5-C2
63-25-2	Carbaryl	Water	Insecticide	6.5	6.5	ng/L	SIR 2012-5206
63-25-2	Carbaryl	Susp. Sed.	Insecticide	6.5	6.5	ng/L	TM5-C2
10605-21-7	Carbendazim	Water	Fungicide	4.2	4.2	ng/L	Hladik et al. 2008
1563-66-2	Carbofuran	Water	Insecticide	3.1	3.1	ng/L	Hladik et al. 2008
1563-66-2	Carbofuran	Susp. Sed.	Insecticide	3.1	3.1	ng/L	Hladik et al. 2008
5234-68-4	Carboxin	Water	Fungicide	4.5	4.5	ng/L	SIR 2012-5206
500008-45-7	Chlorantraniliprole	Water	Insecticide	4.0	4.0	ng/L	SIR 2012-5206
122453-73-0	Chlorfenapyr	Water	Insecticide	3.3	3.3	ng/L	TM5-C2
122453-73-0	Chlorfenapyr	Susp. Sed.	Insecticide	3.3	3.3	ng/L	SIR 2012-5206
1897-45-6	Chlorothalonil	Water	Fungicide	4.1	4.1	ng/L	Hladik et al. 2008
1897-45-6	Chlorothalonil	Susp. Sed.	Fungicide	4.1	4.1	ng/L	Hladik et al. 2008
2921-88-2	Chlorpyrifos	Water	Insecticide	2.1	2.1	ng/L	Hladik et al. 2008
2921-88-2	Chlorpyrifos	Susp. Sed.	Insecticide	2.1	2.1	ng/L	Hladik et al. 2008
5598-15-2	Chlorpyrifos oxon	Water	Insecticide	5.0	5.0	ng/L	Hladik et al. 2008
5598-15-2	Chlorpyrifos oxon	Susp. Sed.	Insecticide	5.0	5.0	ng/L	Hladik et al. 2008
81777-89-1	Clomazone	Water	Herbicide	2.5	2.5	ng/L	Hladik et al. 2008
81777-89-1	Clomazone	Susp. Sed.	Herbicide	2.5	2.5	ng/L	SIR 2012-5206
210880-92-5	Clothianidin	Water	Insecticide	3.9	3.9	ng/L	Hladik et al. 2008
56-72-4	Coumaphos	Water	Insecticide	3.1	3.1	ng/L	SIR 2012-5206
56-72-4	Coumaphos	Susp. Sed.	Insecticide	3.1	3.1	ng/L	Hladik et al. 2008
736994-63-1	Cyantraniliprole	Water	Insecticide	4.2	4.2	ng/L	TM5-C2
120116-88-3	Cyazofamid	Water	Fungicide	4.1	4.1	ng/L	SIR 2012-5206
1134-23-2	Cycloate	Water	Herbicide	1.1	1.1	ng/L	Hladik et al. 2008
1134-23-2	Cycloate	Susp. Sed.	Herbicide	1.1	1.1	ng/L	Hladik et al. 2008
68359-37-5	Cyfluthrin	Water	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
68359-37-5	Cyfluthrin	Susp. Sed.	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
122008-85-9	Cyhalofop-butyl	Water	Herbicide	1.9	1.9	ng/L	Hladik et al. 2008
122008-85-9	Cyhalofop-butyl	Susp. Sed.	Herbicide	1.9	1.9	ng/L	Hladik et al. 2008

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
91465-08-6	Cyhalothrin (all isomers)	Water	Insecticide	0.50	0.50	ng/L	Hladik et al. 2008
91465-08-6	Cyhalothrin (all isomers)	Susp. Sed.	Insecticide	0.50	0.50	ng/L	Hladik et al. 2008
57966-95-7	Cymoxanil	Water	Fungicide	3.9	3.9	ng/L	TM5-C2
52315-07-8	Cypermethrin	Water	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
52315-07-8	Cypermethrin	Susp. Sed.	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
94361-06-5	Cyproconazole	Water	Fungicide	4.7	4.7	ng/L	Hladik et al. 2008
94361-06-5	Cyproconazole	Susp. Sed.	Fungicide	4.7	4.7	ng/L	Hladik et al. 2008
121552-61-2	Cyprodinil	Water	Fungicide	7.4	7.4	ng/L	Hladik et al. 2008
121552-61-2	Cyprodinil	Susp. Sed.	Fungicide	7.4	7.4	ng/L	SIR 2012-5206
1861-32-1	DCPA	Water	Herbicide	2.0	2.0	ng/L	Hladik et al. 2008
1861-32-1	DCPA	Susp. Sed.	Herbicide	2.0	2.0	ng/L	Hladik et al. 2008
3567-62-2	DCPMU	Water	Herbicide	3.5	3.5	ng/L	Hladik et al. 2008
2327-02-8	DCPU	Water	Herbicide	3.4	3.4	ng/L	Hladik et al. 2008
52918-63-5	Deltamethrin	Water	Insecticide	0.60	0.60	ng/L	Hladik et al. 2008
52918-63-5	Deltamethrin	Susp. Sed.	Insecticide	0.60	0.60	ng/L	Hladik et al. 2008
120983-64-4	Desthio-prothioconazole	Water	Fungicide	3.0	3.0	ng/L	Hladik et al. 2008
205650-65-3	Desulfinylfipronil	Water	Insecticide	1.6	1.6	ng/L	Hladik et al. 2008
205650-65-3	Desulfinylfipronil	Susp. Sed.	Insecticide	1.6	1.6	ng/L	SIR 2012-5206
205650-69-7	Desulfinylfipronil amide	Water	Insecticide	3.2	3.2	ng/L	SIR 2012-5206
205650-69-7	Desulfinylfipronil amide	Susp. Sed.	Insecticide	3.2	3.2	ng/L	Hladik et al. 2008
333-41-5	Diazinon	Water	Insecticide	0.90	0.90	ng/L	Hladik et al. 2008
333-41-5	Diazinon	Susp. Sed.	Insecticide	0.90	0.90	ng/L	Hladik et al. 2008
962-58-3	Diazoxon	Water	Insecticide	5.0	5.0	ng/L	Hladik et al. 2008
962-58-3	Diazoxon	Susp. Sed.	Insecticide	5.0	5.0	ng/L	Hladik et al. 2008
62-73-7	Dichlorvos	Water	Insecticide	5.1	5.1	ng/L	Hladik et al. 2008
62-73-7	Dichlorvos	Susp. Sed.	Insecticide	5.1	5.1	ng/L	SIR 2012-5206
119446-68-3	Difenoconazole	Water	Fungicide	10.5	10.5	ng/L	SIR 2012-5206
119446-68-3	Difenoconazole	Susp. Sed.	Fungicide	10.5	10.5	ng/L	Hladik et al. 2008
110488-70-5	Dimethomorph	Water	Fungicide	6.0	6.0	ng/L	Hladik et al. 2008
110488-70-5	Dimethomorph	Susp. Sed.	Fungicide	6.0	6.0	ng/L	Hladik et al. 2008
165252-70-0	Dinotefuran	Water	Insecticide	4.5	4.5	ng/L	Hladik et al. 2008
97886-45-8	Dithiopyr	Water	Herbicide	1.6	1.6	ng/L	Hladik et al. 2008
97886-45-8	Dithiopyr	Susp. Sed.	Herbicide	1.6	1.6	ng/L	Hladik et al. 2008
330-54-1	Diuron	Water	Herbicide	3.2	3.2	ng/L	Hladik et al. 2008
759-94-4	EPTC	Water	Herbicide	1.5	1.5	ng/L	SIR 2012-5206
759-94-4	EPTC	Susp. Sed.	Herbicide	1.5	1.5	ng/L	Hladik et al. 2008
66230-04-4	Esfenvalerate	Water	Insecticide	0.50	0.50	ng/L	Hladik et al. 2008
66230-04-4	Esfenvalerate	Susp. Sed.	Insecticide	0.50	0.50	ng/L	Hladik et al. 2008
162650-77-3	Ethaboxam	Water	Fungicide	3.8	3.8	ng/L	Hladik et al. 2008
55283-68-6	Ethalfluralin	Water	Herbicide	3.0	3.0	ng/L	SIR 2012-5206
55283-68-6	Ethalfluralin	Susp. Sed.	Herbicide	3.0	3.0	ng/L	Hladik et al. 2008

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
80844-07-1	Etofenprox	Water	Insecticide	2.2	2.2	ng/L	Hladik et al. 2008
80844-07-1	Etofenprox	Susp. Sed.	Insecticide	2.2	2.2	ng/L	Hladik et al. 2008
153233-91-1	Etoxazole	Water	Insecticide	4.2	4.2	ng/L	Hladik et al. 2008
153233-91-1	Etoxazole	Susp. Sed.	Insecticide	4.2	4.2	ng/L	Hladik et al. 2008
131807-57-3	Famoxadone	Water	Fungicide	2.5	2.5	ng/L	Hladik et al. 2008
131807-57-3	Famoxadone	Susp. Sed.	Fungicide	2.5	2.5	ng/L	SIR 2012-5206
161326-34-7	Fenamidone	Water	Fungicide	5.1	5.1	ng/L	Hladik et al. 2008
161326-34-7	Fenamidone	Susp. Sed.	Fungicide	5.1	5.1	ng/L	SIR 2012-5206
114369-43-6	Fenbuconazole	Water	Fungicide	5.2	5.2	ng/L	Hladik et al. 2008
114369-43-6	Fenbuconazole	Susp. Sed.	Fungicide	5.2	5.2	ng/L	Hladik et al. 2008
126833-17-8	Fenhexamid	Water	Fungicide	7.6	7.6	ng/L	Hladik et al. 2008
126833-17-8	Fenhexamid	Susp. Sed.	Fungicide	7.6	7.6	ng/L	Hladik et al. 2008
39515-41-8	Fenpropathrin	Water	Insecticide	0.60	0.60	ng/L	Hladik et al. 2008
39515-41-8	Fenpropathrin	Susp. Sed.	Insecticide	0.60	0.60	ng/L	SIR 2012-5206
134098-61-6	Fenpyroximate	Water	Insecticide	5.2	5.2	ng/L	Hladik et al. 2008
134098-61-6	Fenpyroximate	Susp. Sed.	Insecticide	5.2	5.2	ng/L	Hladik et al. 2008
120068-37-3	Fipronil	Water	Insecticide	2.9	2.9	ng/L	TM5-C2
120068-37-3	Fipronil	Susp. Sed.	Insecticide	2.9	2.9	ng/L	Hladik et al. 2008
120067-83-6	Fipronil sulfide	Water	Insecticide	1.8	1.8	ng/L	Hladik et al. 2008
120067-83-6	Fipronil sulfide	Susp. Sed.	Insecticide	1.8	1.8	ng/L	Hladik et al. 2008
120068-36-2	Fipronil sulfone	Water	Insecticide	3.5	3.5	ng/L	Hladik et al. 2008
120068-36-2	Fipronil sulfone	Susp. Sed.	Insecticide	3.5	3.5	ng/L	Hladik et al. 2008
158062-67-0	Flonicamid	Water	Insecticide	3.4	3.4	ng/L	Hladik et al. 2008
79622-59-6	Fluazinam	Water	Fungicide	4.4	4.4	ng/L	Hladik et al. 2008
79622-59-6	Fluazinam	Susp. Sed.	Fungicide	4.4	4.4	ng/L	Hladik et al. 2008
272451-65-7	Flubendiamide	Water	Insecticide	6.2	6.2	ng/L	Hladik et al. 2008
272451-65-7	Flubendiamide	Susp. Sed.	Insecticide	6.2	6.2	ng/L	Hladik et al. 2008
131341-86-1	Fludioxonil	Water	Fungicide	7.3	7.3	ng/L	Hladik et al. 2008
131341-86-1	Fludioxonil	Susp. Sed.	Fungicide	7.3	7.3	ng/L	Hladik et al. 2008
142459-58-3	Flufenacet	Water	Herbicide	4.7	4.7	ng/L	Hladik et al. 2008
142459-58-3	Flufenacet	Susp. Sed.	Herbicide	4.7	4.7	ng/L	Hladik et al. 2008
62924-70-3	Flumetralin	Water	Other	5.8	5.8	ng/L	Hladik et al. 2008
62924-70-3	Flumetralin	Susp. Sed.	Other	5.8	5.8	ng/L	TM5-C2
239110-15-7	Fluopicolide	Water	Fungicide	3.9	3.9	ng/L	Hladik et al. 2008
239110-15-7	Fluopicolide	Susp. Sed.	Fungicide	3.9	3.9	ng/L	Hladik et al. 2008
658066-35-4	Fluopyram	Water	Fungicide	3.8	3.8	ng/L	SIR 2012-5206
658066-35-4	Fluopyram	Susp. Sed.	Fungicide	3.8	3.8	ng/L	TM5-C2
361377-29-9	Fluoxastrobin	Water	Fungicide	9.5	9.5	ng/L	Hladik et al. 2008
361377-29-9	Fluoxastrobin	Susp. Sed.	Fungicide	9.5	9.5	ng/L	SIR 2012-5206
951659-40-8	Flupyradifurone	Water	Insecticide	3.0	3.0	ng/L	Hladik et al. 2008
59756-60-4	Fluridone	Water	Herbicide	3.7	3.7	ng/L	Hladik et al. 2008

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
66332-96-5	Flutolanil	Water	Fungicide	4.4	4.4	ng/L	Hladik et al. 2008
66332-96-5	Flutolanil	Susp. Sed.	Fungicide	4.4	4.4	ng/L	TM5-C2
76674-21-0	Flutriafol	Water	Fungicide	4.2	4.2	ng/L	SIR 2012-5206
76674-21-0	Flutriafol	Susp. Sed.	Fungicide	4.2	4.2	ng/L	SIR 2012-5206
907204-31-3	Fluxapyroxad	Water	Fungicide	4.8	4.8	ng/L	SIR 2012-5206
907204-31-3	Fluxapyroxad	Susp. Sed.	Fungicide	4.8	4.8	ng/L	SIR 2012-5206
51235-04-2	Hexazinone	Water	Herbicide	8.4	8.4	ng/L	SIR 2012-5206
51235-04-2	Hexazinone	Susp. Sed.	Herbicide	8.4	8.4	ng/L	Hladik et al. 2008
35554-44-0	Imazalil	Water	Fungicide	10.5	10.5	ng/L	Hladik et al. 2008
35554-44-0	Imazalil	Susp. Sed.	Fungicide	10.5	10.5	ng/L	SIR 2012-5206
138261-41-3	Imidacloprid	Water	Insecticide	3.8	3.8	ng/L	Hladik et al. 2008
120868-66-8	Imidacloprid urea	Water	Insecticide	4.0	4.0	ng/L	Hladik et al. 2008
173584-44-6	Indoxacarb	Water	Insecticide	4.9	4.9	ng/L	Hladik et al. 2008
173584-44-6	Indoxacarb	Susp. Sed.	Insecticide	4.9	4.9	ng/L	Hladik et al. 2008
125225-28-7	Ipconazole	Water	Fungicide	7.8	7.8	ng/L	SIR 2012-5206
125225-28-7	Ipconazole	Susp. Sed.	Fungicide	7.8	7.8	ng/L	Hladik et al. 2008
36734-19-7	Iprodione	Water	Fungicide	4.4	4.4	ng/L	Hladik et al. 2008
36734-19-7	Iprodione	Susp. Sed.	Fungicide	4.4	4.4	ng/L	Hladik et al. 2008
875915-78-9	Isofetamid	Water	Fungicide	2.0	2.0	ng/L	Hladik et al. 2008
875915-78-9	Isofetamid	Susp. Sed.	Fungicide	2.0	2.0	ng/L	Hladik et al. 2008
143390-89-0	Kresoxim-methyl	Water	Fungicide	4.0	4.0	ng/L	SIR 2012-5206
143390-89-0	Kresoxim-methyl	Susp. Sed.	Fungicide	4.0	4.0	ng/L	Hladik et al. 2008
1634-78-2	Malaoxon	Water	Insecticide	5.0	5.0	ng/L	SIR 2012-5206
1634-78-2	Malaoxon	Susp. Sed.	Insecticide	5.0	5.0	ng/L	Hladik et al. 2008
121-75-5	Malathion	Water	Insecticide	3.7	3.7	ng/L	Hladik et al. 2008
121-75-5	Malathion	Susp. Sed.	Insecticide	3.7	3.7	ng/L	Hladik et al. 2008
374726-62-2	Mandipropamid	Water	Fungicide	3.3	3.3	ng/L	TM5-C2
57837-19-1	Metalaxyl	Water	Fungicide	5.1	5.1	ng/L	Hladik et al. 2008
57837-19-1	Metalaxyl	Susp. Sed.	Fungicide	5.1	5.1	ng/L	Hladik et al. 2008
125116-23-6	Metconazole	Water	Fungicide	5.2	5.2	ng/L	Hladik et al. 2008
125116-23-6	Metconazole	Susp. Sed.	Fungicide	5.2	5.2	ng/L	Hladik et al. 2008
40596-69-8	Methoprene	Water	Insecticide	6.4	6.4	ng/L	TM5-C2
40596-69-8	Methoprene	Susp. Sed.	Insecticide	6.4	6.4	ng/L	Hladik et al. 2008
161050-58-4	Methoxyfenozide	Water	Insecticide	2.7	2.7	ng/L	Hladik et al. 2008
298-00-0	Methyl parathion	Water	Insecticide	3.4	3.4	ng/L	Hladik et al. 2008
298-00-0	Methyl parathion	Susp. Sed.	Insecticide	3.4	3.4	ng/L	Hladik et al. 2008
51218-45-2	Metolachlor	Water	Herbicide	1.5	1.5	ng/L	Hladik et al. 2008
51218-45-2	Metolachlor	Susp. Sed.	Herbicide	1.5	1.5	ng/L	Hladik et al. 2008
88671-89-0	Myclobutanil	Water	Fungicide	6.0	6.0	ng/L	SIR 2012-5206
88671-89-0	Myclobutanil	Susp. Sed.	Fungicide	6.0	6.0	ng/L	SIR 2012-5206
15299-99-7	Napropamide	Water	Herbicide	8.2	8.2	ng/L	Hladik et al. 2008

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
15299-99-7	Napropamide	Susp. Sed.	Herbicide	8.2	8.2	ng/L	Hladik et al. 2008
116714-46-6	Novaluron	Water	Insecticide	2.9	2.9	ng/L	Hladik et al. 2008
116714-46-6	Novaluron	Susp. Sed.	Insecticide	2.9	2.9	ng/L	Hladik et al. 2008
19044-88-3	Oryzalin	Water	Herbicide	5.0	5.0	ng/L	Hladik et al. 2008
19666-30-9	Oxadiazon	Water	Herbicide	2.1	2.1	ng/L	SIR 2012-5206
19666-30-9	Oxadiazon	Susp. Sed.	Herbicide	2.1	2.1	ng/L	Hladik et al. 2008
1003318-67-9	Oxathiapiprolin	Water	Fungicide	3.2	3.2	ng/L	SIR 2012-5206
42874-03-3	Oxyfluorfen	Water	Herbicide	3.1	3.1	ng/L	SIR 2012-5206
42874-03-3	Oxyfluorfen	Susp. Sed.	Herbicide	3.1	3.1	ng/L	Hladik et al. 2008
72-54-8	p,p'-DDD	Water	Insecticide	4.1	4.1	ng/L	TM5-C2
72-54-8	p,p'-DDD	Susp. Sed.	Insecticide	4.1	4.1	ng/L	Hladik et al. 2008
72-55-9	p,p'-DDE	Water	Insecticide	3.6	3.6	ng/L	TM5-C2
72-55-9	p,p'-DDE	Susp. Sed.	Insecticide	3.6	3.6	ng/L	SIR 2012-5206
50-29-3	p,p'-DDT	Water	Insecticide	4.0	4.0	ng/L	TM5-C2
50-29-3	p,p'-DDT	Susp. Sed.	Insecticide	4.0	4.0	ng/L	Hladik et al. 2008
76738-62-0	Paclobutrazol	Water	Fungicide	6.2	6.2	ng/L	Hladik et al. 2008
76738-62-0	Paclobutrazol	Susp. Sed.	Fungicide	6.2	6.2	ng/L	Hladik et al. 2008
40487-42-1	Pendimethalin	Water	Herbicide	2.3	2.3	ng/L	TM5-C2
40487-42-1	Pendimethalin	Susp. Sed.	Herbicide	2.3	2.3	ng/L	SIR 2012-5206
219714-96-2	Penoxsulam	Water	Herbicide	3.5	3.5	ng/L	Hladik et al. 2008
1825-21-4	Pentachloroanisole	Water	Insecticide	4.7	4.7	ng/L	Hladik et al. 2008
1825-21-4	Pentachloroanisole	Susp. Sed.	Insecticide	4.7	4.7	ng/L	Hladik et al. 2008
82-68-8	Pentachloronitrobenzene	Water	Fungicide	3.1	3.1	ng/L	Hladik et al. 2008
82-68-8	Pentachloronitrobenzene	Susp. Sed.	Fungicide	3.1	3.1	ng/L	Hladik et al. 2008
183675-82-3	Penthiopyrad	Water	Fungicide	3.2	3.2	ng/L	Hladik et al. 2008
52645-53-1	Permethrin	Water	Insecticide	0.60	0.60	ng/L	Hladik et al. 2008
52645-53-1	Permethrin	Susp. Sed.	Insecticide	0.60	0.60	ng/L	SIR 2012-5206
26002-80-2	Phenothrin	Water	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
26002-80-2	Phenothrin	Susp. Sed.	Insecticide	1.0	1.0	ng/L	SIR 2012-5206
732-11-6	Phosmet	Water	Insecticide	4.4	4.4	ng/L	Hladik et al. 2008
732-11-6	Phosmet	Susp. Sed.	Insecticide	4.4	4.4	ng/L	TM5-C2
117428-22-5	Picoxystrobin	Water	Fungicide	4.2	4.2	ng/L	SIR 2012-5206
117428-22-5	Picoxystrobin	Susp. Sed.	Fungicide	4.2	4.2	ng/L	Hladik et al. 2008
51-03-6	Piperonyl butoxide	Water	Other	2.3	2.3	ng/L	Hladik et al. 2008
51-03-6	Piperonyl butoxide	Susp. Sed.	Other	2.3	2.3	ng/L	Hladik et al. 2008
29091-21-2	Prodiamine	Water	Herbicide	5.2	5.2	ng/L	Hladik et al. 2008
29091-21-2	Prodiamine	Susp. Sed.	Herbicide	5.2	5.2	ng/L	Hladik et al. 2008
1610-18-0	Prometon	Water	Herbicide	2.5	2.5	ng/L	Hladik et al. 2008
1610-18-0	Prometon	Susp. Sed.	Herbicide	2.5	2.5	ng/L	Hladik et al. 2008
7287-19-6	Prometryn	Water	Herbicide	1.8	1.8	ng/L	Hladik et al. 2008
7287-19-6	Prometryn	Susp. Sed.	Herbicide	1.8	1.8	ng/L	TM5-C2

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
709-98-8	Propanil	Water	Herbicide	10.1	10.1	ng/L	Hladik et al. 2008
709-98-8	Propanil	Susp. Sed.	Herbicide	10.1	10.1	ng/L	Hladik et al. 2008
2312-35-8	Propargite	Water	Insecticide	6.1	6.1	ng/L	Hladik et al. 2008
2312-35-8	Propargite	Susp. Sed.	Insecticide	6.1	6.1	ng/L	Hladik et al. 2008
60207-90-1	Propiconazole	Water	Fungicide	5.0	5.0	ng/L	Hladik et al. 2008
60207-90-1	Propiconazole	Susp. Sed.	Fungicide	5.0	5.0	ng/L	SIR 2012-5206
23950-58-5	Propyzamide	Water	Herbicide	5.0	5.0	ng/L	Hladik et al. 2008
23950-58-5	Propyzamide	Susp. Sed.	Herbicide	5.0	5.0	ng/L	Hladik et al. 2008
175013-18-0	Pyraclostrobin	Water	Fungicide	2.9	2.9	ng/L	Hladik et al. 2008
175013-18-0	Pyraclostrobin	Susp. Sed.	Fungicide	2.9	2.9	ng/L	Hladik et al. 2008
96489-71-3	Pyridaben	Water	Insecticide	5.4	5.4	ng/L	Hladik et al. 2008
96489-71-3	Pyridaben	Susp. Sed.	Insecticide	5.4	5.4	ng/L	Hladik et al. 2008
53112-28-0	Pyrimethanil	Water	Fungicide	4.1	4.1	ng/L	Hladik et al. 2008
53112-28-0	Pyrimethanil	Susp. Sed.	Fungicide	4.1	4.1	ng/L	Hladik et al. 2008
95737-68-1	Pyriproxyfen	Water	Other	5.2	5.2	ng/L	SIR 2012-5206
95737-68-1	Pyriproxyfen	Susp. Sed.	Other	5.2	5.2	ng/L	SIR 2012-5206
124495-18-7	Quinoxyfen	Water	Fungicide	3.3	3.3	ng/L	Hladik et al. 2008
124495-18-7	Quinoxyfen	Susp. Sed.	Fungicide	3.3	3.3	ng/L	Hladik et al. 2008
10453-86-8	Resmethrin	Water	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
10453-86-8	Resmethrin	Susp. Sed.	Insecticide	1.0	1.0	ng/L	Hladik et al. 2008
874967-67-6	Sedaxane	Water	Fungicide	5.2	5.2	ng/L	Hladik et al. 2008
874967-67-6	Sedaxane	Susp. Sed.	Fungicide	5.2	5.2	ng/L	Hladik et al. 2008
122-34-9	Simazine	Water	Herbicide	5.0	5.0	ng/L	SIR 2012-5206
122-34-9	Simazine	Susp. Sed.	Herbicide	5.0	5.0	ng/L	SIR 2012-5206
946578-00-3	Sulfoxaflor	Water	Insecticide	4.4	4.4	ng/L	Hladik et al. 2008
102851-06-9	tau-Fluvalinate	Water	Insecticide	0.70	0.70	ng/L	Hladik et al. 2008
102851-06-9	tau-Fluvalinate	Susp. Sed.	Insecticide	0.70	0.70	ng/L	Hladik et al. 2008
107534-96-3	Tebuconazole	Water	Fungicide	3.7	3.7	ng/L	Hladik et al. 2008
107534-96-3	Tebuconazole	Susp. Sed.	Fungicide	3.7	3.7	ng/L	Hladik et al. 2008
112410-23-8	Tebufenozide	Water	Insecticide	3.0	3.0	ng/L	Hladik et al. 2008
96182-53-5	Tebupirimfos	Water	Insecticide	1.9	1.9	ng/L	Hladik et al. 2008
96182-53-5	Tebupirimfos	Susp. Sed.	Insecticide	1.9	1.9	ng/L	SIR 2012-5206
na	Tebupirimfos oxon	Water	Insecticide	2.8	2.8	ng/L	Hladik et al. 2008
na	Tebupirimfos oxon	Susp. Sed.	Insecticide	2.8	2.8	ng/L	Hladik et al. 2008
79538-32-2	Tefluthrin	Water	Insecticide	0.60	0.60	ng/L	Hladik et al. 2008
79538-32-2	Tefluthrin	Susp. Sed.	Insecticide	0.60	0.60	ng/L	Hladik et al. 2008
112281-77-3	Tetraconazole	Water	Fungicide	5.6	5.6	ng/L	SIR 2012-5206
112281-77-3	Tetraconazole	Susp. Sed.	Fungicide	5.6	5.6	ng/L	Hladik et al. 2008
7696-12-0	Tetramethrin	Water	Insecticide	0.50	0.50	ng/L	Hladik et al. 2008
7696-12-0	Tetramethrin	Susp. Sed.	Insecticide	0.50	0.50	ng/L	Hladik et al. 2008
148-79-8	Thiabendazole	Water	Fungicide	3.6	3.6	ng/L	Hladik et al. 2008

CAS Registry Number	Analyte	Matrix	Reporting group	RL	MDL	Unit	Method
111988-49-9	Thiacloprid	Water	Insecticide	3.2	3.2	ng/L	SIR 2012-5206
153719-23-4	Thiamethoxam	Water	Insecticide	3.4	3.4	ng/L	Hladik et al. 2008
na	Thiamethoxam Degradate (CGA-355190)	Water	Insecticide	3.5	3.5	ng/L	SIR 2012-5206
na	Thiamethoxam Degradate (NOA-407475)	Water	Insecticide	3.4	3.4	ng/L	Hladik et al. 2008
28249-77-6	Thiobencarb	Water	Herbicide	1.9	1.9	ng/L	Hladik et al. 2008
28249-77-6	Thiobencarb	Susp. Sed.	Herbicide	1.9	1.9	ng/L	Hladik et al. 2008
129558-76-5	Tolfenpyrad	Water	Insecticide	2.9	2.9	ng/L	Hladik et al. 2008
43121-43-3	Triadimefon	Water	Fungicide	8.9	8.9	ng/L	Hladik et al. 2008
43121-43-3	Triadimefon	Susp. Sed.	Fungicide	8.9	8.9	ng/L	SIR 2012-5206
55219-65-3	Triadimenol	Water	Fungicide	8.0	8.0	ng/L	Hladik et al. 2008
55219-65-3	Triadimenol	Susp. Sed.	Fungicide	8.0	8.0	ng/L	Hladik et al. 2008
2303-17-5	Triallate	Water	Herbicide	2.4	2.4	ng/L	SIR 2012-5206
2303-17-5	Triallate	Susp. Sed.	Herbicide	2.4	2.4	ng/L	TM5-C2
78-48-8	Tribufos	Water	Herbicide	3.1	3.1	ng/L	TM5-C2
78-48-8	Tribufos	Susp. Sed.	Herbicide	3.1	3.1	ng/L	Hladik et al. 2008
41814-78-2	Tricyclazole	Water	Fungicide	4.1	4.1	ng/L	Hladik et al. 2008
141517-21-7	Trifloxystrobin	Water	Fungicide	4.7	4.7	ng/L	Hladik et al. 2008
141517-21-7	Trifloxystrobin	Susp. Sed.	Fungicide	4.7	4.7	ng/L	Hladik et al. 2008
68694-11-1	Triflumizole	Water	Fungicide	6.1	6.1	ng/L	Hladik et al. 2008
68694-11-1	Triflumizole	Susp. Sed.	Fungicide	6.1	6.1	ng/L	Hladik et al. 2008
1582-09-8	Trifluralin	Water	Herbicide	2.1	2.1	ng/L	Hladik et al. 2008
1582-09-8	Trifluralin	Susp. Sed.	Herbicide	2.1	2.1	ng/L	Hladik et al. 2008
131983-72-7	Triticonazole	Water	Fungicide	6.9	6.9	ng/L	Hladik et al. 2008
131983-72-7	Triticonazole	Susp. Sed.	Fungicide	6.9	6.9	ng/L	Hladik et al. 2008
156052-68-5	Zoxamide	Water	Fungicide	3.5	3.5	ng/L	Hladik et al. 2008
156052-68-5	Zoxamide	Susp. Sed.	Fungicide	3.5	3.5	ng/L	Hladik et al. 2008

7.4.2 Laboratory QC Samples

Data from OCRL (Pesticides chemistry) and MLML (mercury and related parameters) shall include at the least the following QC data:

1. Surrogate recovery (for all environmental and QC samples, where applicable)
2. Method blank
3. Matrix spike recovery (where applicable)
4. Laboratory replicate precision (environmental samples or CRM, matrix spike, blank matrix spike samples when applicable)
5. Certified/lab reference material (CRM/LRM) recovery (where applicable)

Method blanks shall be run at a minimum frequency of one per 20 field samples. Results for laboratory method blanks, combined with those for field blanks, can help identify whether probable causes of sample contamination originated in the field or in laboratory analyses. If both field and lab method blanks have similar levels of contamination, it is likely caused primarily in lab procedures. If field blanks have higher contamination, sample collection methods are likely the cause. Results for method blanks shall be reported.

Matrix spikes (MS) shall be run at a minimum frequency of one per 20 samples. Matrix spike results are to be reported, along with the expected result (unspiked sample concentration + spike concentration), and a recovery estimate. The spiking concentrations should be sufficiently high to quantify recovery (at least 3× the unspiked sample concentration) but also low enough to be a relevant accuracy indicator in the concentration range of field samples (3 - 10x the unspiked sample concentration). In cases where analytes are mostly not detected in unspiked samples, a concentration range of 10×–100× over the MDL may be appropriate to use instead.

Precision can be determined with all sample types analyzed and reported in replicate. Lab replicates (split and analyzed in the laboratory) of field samples are generally the preferred indicator of precision for typical field samples, as the target analyte concentration range, matrix, and interferences are most similar to previous analyzed samples or samples from nearby sites. However, sometimes field sample concentrations are below detection limits for many analytes and replicate results for CRMs, LRMs, MS/MSDs, or blank spikes (LCSs) may be needed to obtain quantitative precision estimates. These alternative sample types, in particular blank spikes (LCSs), should not serve as the primary or exclusive indicator of measurement precision without prior approval by the Program Manager and QAO. LCSs are often created from a clean laboratory matrix and are likely not representative of the measurement precision routinely achievable in more complex matrices of real field-originated samples. The relative percent difference (RPD) should be calculated as described in Section 7.4.3 and reported for all samples analyzed in replicate.

A laboratory control sample (LCS) shall be run at a minimum frequency of one per analytical batch (for analytical batches consisting of up to 20 field samples). Results shall be reported along with the expected values and recoveries (as % of the expected value), where available for target analytes in appropriate matrices.

7.4.3 Precision

Precision measurements will be determined on field and/or laboratory replicates. If samples other than environmental samples are used to evaluate lab precision, target concentrations should be at least high enough to be quantitative but less than 100 times those in environmental samples, as precision in high concentration samples is not likely representative for much lower ambient samples. When using MS/MSD, samples of a similar matrix are most relevant and thus preferred for evaluating precision.

At least one replicate per batch of 20 samples is required. A minimum of one field duplicate per 20, or no less than 5%, of environmental samples will be collected, processed, and analyzed for precision. In addition, a minimum of one environmental sample (or alternative sample type such as a MS, where sample material is insufficient or target analytes are largely not detected in field samples) per batch of samples submitted to the laboratory (minimum one per 20, or 5%, in large batches) will be processed and analyzed in replicate for precision.[13] Previously analyzed material (e.g. from the same project in prior years, or from other projects) may also be analyzed as replicates to help ensure that results are in a quantifiable range. The RPD among replicate samples should be less than the MQO listed in Table 14.2 for each analyte of interest. RPD is calculated as:

$$RPD = \frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2}\right)} \times 100$$

where X_1 and X_2 are independent measurements of the replicate samples.

When more than two replicate samples are collected, the relative standard deviation (RSD) shall be used as a basis of comparison against the MQOs:

RSD = STDEV (all replicate samples) x 100/Average (all replicate samples)

7.4.4 Accuracy

Accuracy is the closeness of a measured result to an accepted reference value. Accuracy shall be measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples (LCS), spiked samples (matrix spikes and matrix spike duplicates), internal standards, surrogate recoveries, initial calibration, and calibration checks.

[13] For example, if there were 61 samples, 4 environmental samples would be processed and analyzed in replicate for precision.

The accuracy of lab measurements will be evaluated based on measurement quality objectives (Table 14.2).

For a matrix spike, a known quantity of an analyte added to a sample to test whether the response to a sample is the same as that expected from a calibration curve. These samples are useful for determining whether elements of the matrix (the remainder of the sample other than the analyte) influence the results of the measurement. The percent recovery for spiked samples is calculated using the equation:

$$\%\ recovery = \frac{\left(C_{spiked\ sample} - C_{unspiked\ sample}\right)}{C_{added}} \times 100$$

The percent recovery for LCS and surrogates is calculated using the equation

$$\%\ \text{recovery} = \frac{\text{analyzed concentration of LCS or surrogate}}{\text{certified concentration of LCS or surrogate}} \times\ 100$$

Table 7.4 lists recovery surrogate standards used for pesticide analyses and associated measurement quality objectives.

Table 7.4 Recovery surrogate standards used for pesticide analyses and associated measurement quality objectives.

Recovery surrogate standard	Matrix	Method	Acceptable limits (% recovery)
$^{13}C_3$-atrazine	Water	TM-5-C2	70%–130%
Di-N-propyl-d_{14} trifluralin	Water	TM-5-C2	70%–130%
Monuron	Water	USGS – SIR 2012-5026	70%–130%
Imidacloprid-d_4	Water	USGS – SIR 2012-5026	70%–130%

7.4.5 Contamination

For laboratory analyses, at least one laboratory method blank will be run for each 20 field samples. The method blank will be processed throughout the entire analytical procedure in a manner identical to the samples (i.e., using the same reagents and equipment). Method blanks should contain analyte concentrations less than the MDL. A method blank concentration > MDL for any analytes of interest will require corrective action (e.g., checking of reagents, re-cleaning and re-checking of equipment) to identify and eliminate the source(s) of contamination before proceeding with sample analysis. If eliminating the blank contamination and reanalysis is not possible, results for all impacted analytes in the analytical batch shall be flagged. In addition, a detailed description of the contamination sources and the steps taken to identify and eliminate/minimize them shall be included in the transmittal letter. Method blanks may or may not be subtracted from reported results, based on the method and/or laboratory SOP employed. A "LabBatch" comment will be included that indicates whether the sample results in that batch are blank corrected or not.

8 Special Training or Certifications

Laboratories must have a designated on-site QA Officer for the particular analytical component(s) performed at that laboratory. This individual will serve as the point of contact for the SFEI-ASC QA staff in identifying and resolving issues related to data quality.

To ensure that the samples are analyzed in a consistent manner throughout the duration of the program, key laboratory personnel will participate in an orientation session conducted during an initial site visit or via communications with SFEI-ASC staff. The purpose of the orientation session is to familiarize key laboratory personnel with this QAPP and the Delta RMP QA/QC program. Participating laboratories will be required to demonstrate acceptable performance before analysis of samples can proceed. Laboratory operations will be evaluated on a continuous basis through technical systems audits and by participation in laboratory intercomparison programs.

Personnel in any laboratory performing analyses will be well versed in good laboratory practices (GLPs), including standard safety procedures. It is the responsibility of the analytical laboratory manager and/or safety staff to ensure that all laboratory personnel are properly trained. Each laboratory is responsible for maintaining a current safety manual in compliance with Occupational Safety and Health Administration (OSHA) or equivalent state or local regulations. The safety manual will be readily available to laboratory personnel. Proper procedures for safe storage, handling, and disposal of chemicals will be followed at all times. Each chemical will be treated as a potential health hazard and GLPs will be implemented accordingly.

Personnel collecting samples will be trained in the field sampling methods described in the QAPP. For mercury monitoring, the MPSL project coordinator will be responsible for training the MPSL field staff. For nutrient monitoring, the USGS principal investigators will be responsible for training the USGS field staff. For all field trainings, staff shall maintain a record of field trainings given. Information will include trainer, trainees, and dates of training. The sign-in sheet of the training can be the documentation of the training.

8.1 Training Certification and Documentation

Contractors performing sampling are responsible for providing training to their staff and maintaining records of all trainings. Those records can be obtained if needed from contractors through their respective QA or Safety Officers.

8.2 Training Personnel

Each contract laboratory's QA Officer and Safety Officer shall provide and/or designate staff to provide training to their respective personnel. All personnel responsible for sampling will be trained in field sample collection and safety prior to the first day they are schedule to sample for the Delta RMP.

9 Documentation and Records

All Delta RMP documents will be provided to the Steering Committee, which includes the Regional Board.

SFEI-ASC will collect records for sample collection, field analyses, and laboratory chemical analyses. Samples sent to analytical laboratories will include a Chain-of-Custody (COC) form. The analytical laboratories will maintain records of sample receipt and storage, analyses, and reported results.

SFEI-ASC will maintain hardcopy or scanned files of field notes and measurements as well as documentation and results submitted by laboratories at the SFEI-ASC main office. The SFEI-ASC Data Manager will be responsible for the storage and organization of information.

Contract laboratories will be responsible for maintaining copies of project documentation originating from their respective laboratories, with backup archival storage offsite where possible. All SOPs used for the Delta RMP will be stored indefinitely, in case future review is necessary.

9.1 Quality Assurance Documentation

All laboratories will have the latest revision of the Delta RMP QAPP. In addition, the following documents and information will be current and available to all laboratory personnel participating in the processing of project samples and to SFEI-ASC program officials:

1. Field Standard Operating Procedures (SOPs): Containing instructions for fieldwork activities, including procedures for conducting field observations, field measurements, and environmental sample collection. Describe requirements for sample containers, volume, preservation, and storage.
2. Laboratory Quality Management Plan: clearly defined policies and protocols specific to a particular laboratory, including policies and objectives, organizational authority, personnel responsibilities, and internal performance measures.
3. Laboratory Standard Operating Procedures (SOPs): containing instructions for performing routine laboratory procedures (such as logging, labelling, and storage of samples; cleaning of equipment; checking of reagents) that are not necessarily part of any analytical methodology for specific analytes or analyte types.
4. Laboratory Analytical Methods: step-by-step instructions describing exactly how a method is implemented in the laboratory for a particular analytical procedure. Contains all analytical methods utilized in the particular laboratory for services provided to the Delta RMP.
5. Instrument Performance Information: information on instrument baseline noise, calibration standard response, analytical precision and bias data, detection limits, etc. This information shall be reported for the periods during which Delta RMP samples are analyzed.
6. Control Charts: control charts are useful in evaluating internal laboratory procedures and are helpful in identifying and correcting systematic error sources. Contract laboratories are encouraged to develop and maintain control charts whenever they may serve in determining sources of analytical problems.

Copies of laboratory methods, SOPs, and QA plans are available by request from the SFEI-ASC QA Officer. Some laboratory methods and SOPs may be edited to exclude proprietary details about the analyses. Quality assurance documents are reviewed to assure conformance to program needs by the Delta RMP Program Manager and QAO or their designees.

Hand-written original field sheets, logs, and calibration records will be maintained by the field sample collection teams.

Copies of all records will be maintained at SFEI-ASC and at the laboratory for a minimum of five years after project completion, after which they may be discarded, except for the database at SFEI-ASC, which will be maintained without discarding. All data will be backed up and secured at a remote location (i.e., separate from the SFEI-ASC office). As needed, data recovery can be initiated by contacting the back-up facility for restoration and this will be covered through SFEI-ASC overhead.

All participants listed in Table 3.1 will receive the most current version of the Delta RMP QAPP.

9.2 Standard Operating Procedures (SOPs)

The SOPs are listed in Appendix E in this QAPP. The QA Officer and Project Manager shall approve any changes in methods.

10 Sampling Process Design

10.1 Study Area and Period

Sample collection points and a justification for site selection and study areas for the different elements are described in the specific designs for each of the Delta RMP monitoring elements (Appendix D. Short Summaries of Delta RMP Monitoring Elements, page 165). Delta RMP monitoring occurs in, upstream, and downstream of the Delta (Figure 6.3 and Figure 6.4). The monitoring sites for mercury sampling represent different subareas of the Delta (Figure 6.3). Cruise tracks for nutrient monitoring represent nutrient gradients and under-monitored areas in the Delta (Figure 6.4).

Sampling timing and frequency varies for the different elements of the monitoring program:

- Mercury monitoring includes annual sport fish sampling at 6 sites, and co-located water and sediment sampling at the same 6 sites. Water will be sampled 8 times per year, and sediment will be sampled 4 times per year. Both sportfish and water sampling started in 2016. Sediment sampling will begin in 2017.
- Nutrient monitoring will consist of research cruises along transects of the North, Central, and South Delta that will be conducted three times on three successive days in October of 2017 and May and August of 2018.

Sampling for pesticides and aquatic toxicity will be conducted over 6 events during the water year, designed to capture a range of hydrologic conditions and periods of the agricultural calendar. Among the 6 planned events, 3 are for storm sampling, and 3 for dry weather / irrigation season. It is necessary to space sampling events by at least 2 weeks so the labs can

process all the samples from the previous round. Planned timing of sampling events is shown in Table 6.7 on page 62. Samples will be taken on the ebb tide, if possible.

The Delta is a highly dynamic and hydrologically complex system. Seasonal and temporal variability of target analytes within the system is shaped by numerous influencing factors, including the relative contributions of source waters and their chemical composition, seasonal and temporal variability in loads, biogeochemical processes within the system, seasonally-varying process rates, flow rates and flow routing, climate variability, and habitat-specific (local) factors. Therefore, study design and data evaluation should always take into consideration co-variance of and potential bias caused by influencing factors.

Collected data are used to evaluate future data needs and adjust the sampling and analysis plan as needed to optimize data collection in an adaptive manner. The program will be continually adjusted to optimize data collection. The monitoring design is described in Annual Workplans on the project website:
https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/wq_monitoring/

10.2 Sampling Sites

Table 10.1 summarizes information on sampling sites and schedule. In the case that a site is inaccessible, the field team lead will inform the SFEI-ASC Program Manager. Alternative options will be discussed with the mercury or nutrient subcommittee and the TAC and decided by the SC.

Table 10.1 Sampling sites and schedule.

Site Name	CEDEN Site Code	Target Latitude	Target Longitude	Sampling frequency	Schedule
Mercury Monitoring					
1. Cache Slough at Liberty Island Mouth	510ADVLIM	38.24213	-121.68539	**Sportish**: Once Annually **Water:** 10 times/year	**Sportfish:** August 2018: **Water**: 1. July 2018 2. August 2018 3. September 2018 4. October 2018 5. Nov or Dec 2018 6. Jan or Feb 2019 7. March 2019 8. April 2019 9. May 2019 10. June 2019
2. Little Potato Slough	544LILPSL	38.09627	-121.49602		
3. Middle R @ Borden Hwy (Hwy 4)	544MDRBH4	37.89083	-121.48833		
4. Lower Mokelumne R 6	544ADVLM6	38.25542	-121.44006		
5. Sacramento R @ Freeport	510ST1317	38.45556	-121.50189		
6. San Joaquin R @ Vernalis/Airport Way	541SJC501	37.67556	-121.26417		
7. Sacramento River at Mallard Island	207SRD10A	38.04288	-121.92011		
8. Delta-Mendota Mendota Canal at Byron-Bethany Road (Water only; no sportfish sampling at this site.)	544DMC020	37.81239	-121.57887		
Nutrients					
Cruise Track A	Launch at Miller Park or Garcia Bend and head downstream to Old River and Middle River via Georgianna Slough and Mokelumne River. End at Rio Vista.			3 times/year	Day 1 of 3 successive days in October, May, August
Cruise Track B	From Rio Vista, upstream on the Sacramento River to Delta Cross Channel and explore more of the Mokelumne (North and South branches) and adjacent sloughs to extend feasible, then upstream as far as possible on the San Joaquin River. Return to Rio Vista.				Day 2 of 3 successive days in October, May, August
Cruise Track C	From Rio Vista, circumnavigate the Cache Slough Complex, head downstream on the Sacramento River to the Confluence with the San Joaquin River and onward to Honker Bay and Grizzly Bay. Head upstream on the San Joaquin River and return to Rio Vista via Three Mile Slough.				Day 3 of 3 successive days in October, May, August
Pesticides and Aquatic Toxicity					

Site Name	CEDEN Site Code	Target Latitude	Target Longitude	Sampling frequency	Schedule
San Joaquin River at Buckley Cove	544LSAC13	37.9718	-121.3736	6 x per year	3 wet-weather events, and 3 dry-weather events per Water Year. See Table 6.7 on page 62.
Ulatis Creek at Brown Road	511ULCABR	38.3070	-121.7942	6 x per year	
Probabilistic or Random sites chosen with GRTS	None	Varies, see Table 6.4 on page 57.		Each site sampled one time only; 6 sampling events per year	

For pesticides sampling, occasionally, one of the randomly-selected sampling locations will not be accessible because it is unsafe, on private property, etc. In this case, a sample should be taken within 100 meters if possible and only if there is not some obvious change in the environment, such as moving downstream of an outfall, a change in water clarity, etc. If not possible to sample within 100 m, the crew should choose the next site on the "oversample" list shown above in Table 6.4.

11 Sampling (Sample Collection) Methods

11.1 Field Sample Collection

11.1.1 Equipment Cleaning and Decontamination Procedures

Mercury Sampling

Equipment cleaning and decontamination procedures are documented in MPSL SOPs MPSL-102b, Section 7, and MPSL-111, Section 7. To avoid cross-contamination, all equipment used in sample collection will be thoroughly cleaned before each sample is processed. Before the next sample is processed, instruments will be washed with a detergent solution (Micro™), rinsed with ambient water, rinsed with a high-purity solvent (methanol or petroleum ether), and finally rinsed with Milli-Q® water. Waste detergent and solvent solutions must be collected and taken back to the laboratory. Boats, sampler, and personal protection equipment (PPE) will be pre-cleaned with 10% bleach to prevent introducing invasive species from one water body to another water body.

Underway Flow-through System

The flow-through system is rinsed thoroughly with organic free water (OFW) after each use (within 24 hours) and stored with OFW in the flow path between uses. A blank is collected before and after each field outing to verify cleanliness of the system and verify instrument

offsets. If a blank fails, instruments are cleaned with lens paper, and if necessary, isopropyl alcohol.

The sample pump is thoroughly rinsed and scrubbed. Tubing is changed between uses.

The water quality sonde (YSI EXO) flow-through cup and pre-filter are cleaned with hot tap water and Liquinox® detergent, rinsed with deionized water (DI), and rinsed with OFW after each use.

Tubing that delivers water from manifold to instrumentation is replaced after each field use.

Chlorophyll *a* filter supplies (filter towers, filter pad holder, tweezers) undergo a hot Liquinox soak for a minimum of 24 hours. They are then thoroughly rinsed with hot tap water to remove Liquinox, followed by a DI rinse, and an OFW rinse. Filter towers are then rinsed with acetone. They are left in a fume hood overnight to allow acetone to evaporate off. They receive a final rinse with OFW before use. Materials are placed in plastic bags when stored (EPA Method 445.0).

11.1.2 Collection of Water Samples for Analysis of Mercury and Methylmercury

Samples will be collected according to MPSL Field SOP v1.1 (see Appendix E for link) and standard trace metal clean-hands/dirty-hands collection methods where appropriate to avoid sample contamination. A depth-integrated sample will be collected following MPSL Field SOP v1.1 using a bucket sampler (as described in MPSL-111). Briefly, a web of clean C-Flex tubing is used to hold the bottle in place while sampling. Tubing will be replaced prior to each sampling event or sooner, if thought to have come in contact with surfaces known to be possible contamination sources, such as the boat deck. Plastic-covered lead weights are fastened with plastic fasteners to the outside bottom of the bucket to allow sufficient weight to lower the sampler through the water column. A clean polypropylene line is attached to the bucket and used to lower and raise the sampler through the water column. The sampling bucket and line will be kept clean by storing in new clean plastic bags between uses and not allowing contact with surfaces on the sampling platform that are known to be potential sources of contamination.

A depth-integrated sample will be collected by lowering and raising the 4L bottle through the water column at a sufficient rate so that the bottle is not completely filled upon retrieval. A new pre-cleaned 4L glass bottle (MPSL-101 Sample Container Preparation for Organics and Trace Metals, including Mercury and Methylmercury) will be used for each site.

Section 12.1 describes field sample handling and shipping procedures and Table 12.1 provides information on storage and hold time requirements.

11.1.3 Collection of Water Samples for Nutrient Analyses

Samples for nutrient analyses (nitrate-nitrite, ammonium, and orthophosphate) will be collected at 0.5-m depth through Tygon brand flexible polymer tubing using the onboard diaphragm pump. The samples will be filtered using a 0.2-μm membrane filter before collection in clean glass bottles. The sampling procedure is described in detail in Table 11.1 in the USGS *National Field Manual for the Collection of Water Quality Data* ().

Samples for chlorophyll-*a* analysis will be collected and field-filtered within 24 hours of collection using a syringe sample method (USEPA Method 445). Samples will be filtered by forcing water with a 60-mL syringe through an inline filter holder containing a 25-mm glass microfiber filter. The 60-mL syringe and inline filter holder are rinsed three times with ambient water before filtration. The syringe is then filled with 60 mL of ambient water. The filter holder is then removed and a 25-mm glass microfiber filter is placed inside. The filter holder is then screwed back onto the syringe and ambient water is flushed through the filter. The filter holder is removed every time more water needs to be drawn into the syringe. The process will be repeated until the desired amount of chlorophyll *a* is present (usually 60 to 360 mL, depending on turbidity). When filtering is complete, the filter holder is opened and the filter is removed with tweezers without touching the filtrate. The filter is folded in half, then in quarters, with the chlorophyll *a* inside the folds. The folded filter is then wrapped in aluminum foil and placed in an envelope labeled with the site information and the volume filtered. The envelope is immediately placed on dry ice until transferred to USGS-OMRL. Upon arrival at the analytical lab, the temperature of the cooler is measured and recorded to verify samples were maintained at the appropriate temperature.

Samples for chlorophyll-*a* analysis in chlorophyll-containing particles > 5 μm in diameter will be identical to the total chlorophyll-*a* analysis described above except that a 5 μm membrane filter will be used.

11.1.4 Collection of Sediment Samples for Analysis of Mercury, Methylmercury, and Sediment Characteristics

Sediment samples for mercury monitoring are collected 4 times per year. References and links for accessing SOPs for sediment sample collection are provided in Appendix E.

Sediment will be collected in accordance with MPSL- 102b Field Collection Procedures for Bed Sediment Samples, Section 8.2 or 8.3, at the same site where water is collected, after water sample collection is complete (MPSL Field SOP v1.1). Sediment samples will be collected from the thalweg and the shoal at each site. Field crews will evaluate each site to determine the correct method to be employed. Specific rejection criteria are found in MPSL Field SOP v1.1, page 59.

Only the top 2 cm of the collected material will be transferred to the sample containers using a pre-cleaned polyethylene scoop. Sediment for mercury and TOC analysis will be frozen immediately upon collection by placing them on dry ice. Sediment for grainsize analysis will be stored on wet ice. Upon arrival at the analytical lab the temperature of the cooler is measured and recorded to verify samples were maintained at the appropriate temperature.

11.1.5 Collection of Fish Tissue for Analysis of Mercury and Methylmercury

Sport fish samples for mercury monitoring are collected annually. The appropriate sample collection method may vary by site and will be determined by the MPSL field sample collection team.

References and links for accessing SOPs for fish sample collection are provided in Appendix E.

Fish will be collected in accordance with MPSL-102a Sampling Marine and Freshwater Bivalves, Fish and Crabs for Trace Metal and Synthetic Organic Analysis; Section 7.4. Because habitats may vary greatly, there is no one method of collection that is appropriate. Field crews will evaluate each fishing site to determine the correct method to be employed. Potential sampling methods include but are not limited to: electroshocking, seining, gill netting, and hook and line. Field crew will determine the appropriate collection method based on physical site parameters such as depth, width, flow, and accessibility. Field crew will indicate the collection method on data sheets (Appendix F).

The targeted fish species is largemouth bass. The goal is to collect 16 individuals spanning a range of total length from 200 to greater than 407 mm at each site (Table 11.2). Specimens of similar predator species may be collected, if the desired number of individuals of the primary target fish species in the desired size range cannot be collected at a site. (Section 12.1 provides more information on field sample handling and shipping procedures. Table 12.1 provides information about storage and hold time requirements for each parameter group.)

Further details on sample collection can be found in MPSL-102a, Section 7.4 (see Appendix E for link).

Fish will be processed according to MPSL- 102a Sampling Marine and Freshwater Bivalves, Fish and Crabs for Trace Metal and Synthetic Organic Analysis; except where noted here. Collected fish will be partially dissected in the field. At the dock, the fish is placed on a measuring board covered with clean aluminum foil or plastic. Fork and total length are recorded. Weight is recorded, if the fish is large enough for the scale. If the fish is too large to fit in the bag, it will then be placed on the covered cutting board, where the head, tail, and guts are removed using a clean cleaver (scrubbed with Micro™, rinsed with tap and deionized water). The fish cross-section is tagged with a unique numbered ID, wrapped in aluminum foil, and placed in a clean labeled bag. When possible, parasites and body anomalies are noted. The cleaver and cutting

board are re-cleaned with Micro™, rinsed with tap and deionized water between fish species. The equipment cleaning procedures will be repeated at each sampling site.

11.1.6 Collection of Water Samples for Pesticides and Aquatic Toxicity Analysis

Samples for pesticides and toxicity monitoring shall be collected concurrently as grab samples 0.5 meters below the water surface. All water samples shall be collected as grab samples in accordance with the following methods described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The study design calls for grab samples due to the large volume of water (approximately 45 liters) required for collecting toxicity and pesticide samples concurrently, even in hydrologic conditions that might otherwise dictate integrated sampling techniques. Samples shall be collected between the high and low tide, or on the ebb tide (for tidally influenced sites) by submerging narrow-mouthed bottles at mid-channel to a depth of 0.5 m. At the two fixed monitoring sites, during low flow conditions, samples may be collected by wading into streams and submerging handheld bottles. In high flow conditions or for sites with difficult bank access, samples shall be collected from bridges using weighted-bottle samplers.

At the probabilistic (random) sites chosen by GRTS, samples will be collected by boat using the weighted bottle sampler. Water samples for pesticide and toxicity analyses will be collected by submerging 1 L baked amber glass bottles (pesticides), 3L Teflon (copper and DOC), and 4 L glass (toxicity) to a depth of 0.5 m using weighted bottle samplers. Samples will be collected on an ebb tide if logistically feasible. The sampling boat will be maintained on station at the GRTS site throughout the sample collection process.

Pesticide samples shall be collected in pre-cleaned, baked 1-liter (L) glass amber bottles and transported on ice to the USGS OCRL in Sacramento, Calif. for processing and analysis using a combination of liquid chromatography tandem mass spectrometry (LC/MS/MS) and gas chromatography mass spectrometry (GC/MS). Samples for analysis at the USGS NWQL (Copper, DOC, PIC, POC, TPC, and TPN) shall be collected in 3-L TeflonTM bottles, processed at the USGS California Water Science Center, and shipped on ice to the USGS NWQL in Denver, Colo.

Toxicity samples shall be collected in pre-cleaned 4-L glass amber bottles provided by the Aquatic Health Program Laboratory at UC Davis. Bottles shall be triple rinsed with native water on-site before sample collection. Bottles shall be transported on ice to the AHPL for analysis.

Basic water-quality measurements (water temperature, specific conductance, dissolved oxygen, pH, and turbidity) shall be taken at a depth of 0.5m at mid-channel during each sample collection using a YSI 6920V2 multi-parameter meter. The meter shall be calibrated using appropriate procedures and standards prior to sample collection as described in the USGS National Field Manual (U.S. Geological Survey, variously dated).

11.1.7 Habitat Observations

The field crew collecting pesticides and toxicity water samples shall make a number of observations about the sampling location, and record these on a field sampling data sheet. These observations are somewhat confusingly referred to (by USGS, SWAMP and others) as "habitat parameters," even though this project is not specifically monitoring wildlife habitat. Table 11.1 shows the elements to be recorded by field crews on the SWAMP field data sheet.[14]

In the past, Delta RMP pesticides monitoring visited the same 5 sites monthly, and therefore, each site was well known to us, and there was not much to be gained from these observations. However, as the project will be monitoring dozens of new, randomly-selected locations, it will be important to record conditions at each site, particularly anything out of the ordinary. These observations may be useful for interpreting the pesticide and toxicity results for that station.

[14] https://drive.google.com/file/d/0B40pxPC5g-D0WTBmZlkzOHE0dnM/view

Table 11.1 Habitat parameters recorded by field crews at each sampling location.

Parameter	Possible responses
Site odor	None, Sulfides, Sewage, Petroleum, Smoke, Other
Sky code	Clear, Partly cloudy, Overcast, Fog, Smoky, Hazy
Other presence	Vascular, Nonvascular, Oily Sheen, Foam, Trash, Other
Dominant substrate	Bedrock, Concrete, Cobble, Boulder, Gravel, Mud, Unknown, Other
Water clarity	Clear (see bottom), Cloudy (>4" visibility), Murky (<4" visibility)
Water odor	None, Sulfides, Sewage, Petroleum, Mixed, Other
Water color	Colorless, Green, Yellow, Brown
Overland runoff (last 24 hours)	None, light, moderate/heavy, unknown
Observed flow	NA, Dry Waterbody bed, No Observed Flow, Isolated Pool, Trickle (<0.1 cfs), 0.1 - 1 cfs, 1-5cfs, 5-20 cfs, 20-50cfs, 50-200cfs, >200cfs
Wadeability	Yes, No, Unknown
Wind speed (Beaufort scale)	0–12
Wind direction	
Precipitation (at time of sampling)	None, Fog, Drizzle, Rain, Snow
Precipitation (last 24 hours)	Unknown, <1", >1"
Occupation Method	Walk-in, Bridge, Other
Starting bank (facing downstream)	Left bank, Right bank, Not applicable
Distance from bank (m)	
Stream width (m)	
Water depth (m)	
Location	Bank Thalweg, Mid-channel, Open Water
Hydromodification	None, Bridge, Pipes, Concrete channel, Grade control, Culvert, Aerial zipline, Other

Table 11.2 Sample container type and volume used for each parameter group for collection of water and sediment samples; and target species, number of individuals, and size ranges for collection of fish tissue samples.

Water				
Program Element	**Parameter Group**	**Bottle type[15]***	**Number of bottles/event**	**Sample Volume/Site**
Mercury	Trace metals Conventional[16]	Clear glass	7	4L
Nutrients	Nutrients Conventional	Amber glass or P Polypropylene	50	125 mL
Nutrients	Chl-*a*, chl-*a* > 5 µm	Amber glass	90	Requirement varies; typically 200-500 mL for both
Pesticides	Pesticide suite	Amber glass	16 – 20, depending on number of QC samples planned for the event	1L
Pesticides	Copper, DOC, PIC, POC, TPC, and TPN	Teflon	8	3L
Aquatic Toxicity	Toxicity	Amber glass	80	4L
Sediment				
Program Element	**Parameter Group**	**Container Type[17]***	**Number of containers/event**	**Target Sample Size/Site**
Mercury	Conventional[18]	Polypropylene jar or WhirlPac bag	13	60 mL
Mercury	Trace metals	Glass jar	13	60 mL
Fish				
Program Element	**Parameter Group**	**Primary Target[19]**	**Number of Individuals**	**Individuals/ Site (Size)**
Mercury	Mercury	Largemouth Bass	96	16 total: 3X(200-249 mm), 3X(250-304 mm), 7X(305-407 mm), 3X(>407 mm)

[15] References: MPSL Field SOP v1.1 (mercury); National Field Manual for the Collection of Water Quality Data (nutrients and conventional), and USEPA Method 445 (chlorophyll). Appendix E provides links to these documents.

[16] Conventional parameters (DOC, TSS, VSS) will be analyzed in sample aliquots.

[17] Reference: MPSL- 102b Field Collection Procedures for Bed Sediment Samples, Sections 8.2 and 8.3 (see Appendix E for link).

[18] TOC, grain size.

[19] Delta RMP Monitoring Design (revised June 16, 2015).

11.2 Field Sample Collection Quality Control Samples and Measurement Quality Objectives

Required field sample collection QC samples include field blanks and field duplicates. All field sample collection QC samples will be collected at a rate of no less than 5% each. Field QC samples shall be planned and collected throughout the project to evaluate potential variability sources in the field; including differing environmental conditions, geographic locations, sample collection personnel, and various field sampling protocols employed. Field blanks are required for water sample collection for analysis of mercury, methylmercury, current use pesticides, aquatic toxicity, total suspended solids (TSS), and volatile suspended solids (VSS). Field duplicates are required for all water and sediment samples. Field sample quality controls and measurement quality objectives are included in Table 14.1.

11.3 Field Sample Collection Corrective Actions

Table 11.3 lists typical corrective actions that may be taken by the project manager and/or QA Officer in response to issues that arise as a result of field sampling procedures. All necessary steps for corrective action will be documented on the field form and are entered into the electronic version of the Field Sampling Report that is maintained by SFEI-ASC. The individuals responsible for assuring that the field staff are properly trained and implement the Field Sampling SOPs are the Field Collection Coordinators (i.e., MPSL Project Coordinator and USGS Principal Investigators, OCRL Project Chief), SFEI-ASC Project Manager, and the QA Officer.

Table 11.3 Corrective actions procedures for field QC samples.

Field QC Sample Type	Corrective action
Field Blank, Equipment Blank, Travel/Bottle Blank (Water)	If target analytes are found in field blanks, sampling and handling procedures will be reevaluated and corrective actions taken. These may consist of, but are not limited to, a) obtaining sampling containers from new sources, b) training of personnel, c) discussions with the laboratory, d) invalidation of results, e) greater attention to detail during the next sampling event, or f) other procedures deemed appropriate.
Field Replicate (Water, Sediment, Tissue)	If criteria are exceeded, field sampling and handling procedures will be evaluated and problems corrected through greater attention to detail, additional training, revised sampling techniques, or other procedures deemed appropriate to correct the problems.

12 Sample Handling and Custody

This section describes the sample handling and custody procedures from sample collection through transport and laboratory analysis.

Table 12.1 provides information about storage and hold time requirements for each type of water quality measurement.

12.1 Pesticides

Sample containers will be labeled with the location, date, and time collected and packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets and chain-of-custody forms (COC) will be filled out at the time of collection and will include site ID, site description, collection date/time, container type, sample preservation, field water chemistry measurements, sampler(s) name and requested analyses. All forms will be included with the appropriate samples during shipping. Samples for pesticide analysis will be delivered to the USGS OCRL laboratory in Sacramento California. If upon arrival at the OCRL samples are found to be warm (ice melted) or if sample containers are broken the Project Manager and Principal Investigator will be immediately notified. Ice chests are examined upon delivery to ensure that samples have been properly chilled (acceptable temperature range = 0 to 6 °C).

Water samples for pesticide analyses will generally be processed to extraction upon arrival at the OCRL. If this is not possible, the samples will be refrigerated at 0 to 6 °C in the dark for a period not to exceed the OCRL holding time requirement of 48 hours between sample collection and extraction. Upon arrival of samples, appropriate laboratory processing forms noting unique laboratory ID, site name, collection time and date, receiving technician's name, requested analysis, and date and time of receipt will be filled out. Signed copies of COCs will be maintained with the appropriate OCRL field and laboratory forms.

Samples for dissolved copper analysis and DOC/POC analysis will be processed at the USGS OCRL, within 24 hours of collection. Samples for dissolved copper analysis will be filtered using 0.45-micrometer (μm) filters and acidified to pH less than 2 with 2 mL of 7.5N nitric acid. Samples for DOC analysis will be filtered using 0.7 μm pore size, pre-combusted glass-fiber filters, collected in 125-mL baked amber glass bottles, and acidified using 4.5N sulfuric acid. The 0.7 μm pore size filter holding the retained suspended material will be used for the POC analysis and will be wrapped in an aluminum foil square of appropriate size.

Samples for dissolved copper, DOC, and POC will be placed in a cooler on wet ice and shipped overnight to the USGS NWQL in Lakewood, CO.

Receipt temperature and sample condition (broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by receiving laboratories.

12.2 Toxicity Testing

Toxicity test samples will be delivered to the Aquatic Health Program Laboratory (AHPL) at UC Davis, California, within 24 hours of sample collection. Upon arrival at AHPL, toxicity testing samples will be immediately removed from the ice chests and the laboratory staff receiving the coolers will complete the accompanying Chain of Custody form (COC). The AHPL will initiate tests within 36 hours of sample collection, although under rare circumstances, this holding time may be extended to 120 hours for storm events, when courier

delivery schedules on weekends and holidays limit the availability of test organisms. In these instances, AHPL staff will notify the SFEI-ASC QAO and Project Manager, and associated data will be flagged appropriately for minor hold time violation.

Table 12.1 Storage and hold time requirements for each parameter group.

Parameter group	Storage (Collection to Extraction, where applicable)	Hold time (Collection to Extraction, where applicable)	Hold time (Extraction to analysis, where applicable)	Storage (Extraction to analysis, where applicable)
Ammonium (Water)	4 ±2°C in dark	Cool to 4 ±2°C and preserve with 2 mL of H_2SO_4 per L within 48 hours of collection	28 day, if acidified	4 ±2°C
Chlorophyll *a* (Water)	0 to 6°C in dark	Filtration within 24 hours of collection	28 days	–20°C in dark
DOC (Water)	0 to 6°C in dark	Filtration within 24 hours of collection	DOC: 30 days/ POC: 100 days	0 - 6°C in dark
Mercury, total (Sediment)	≤ 6°C	Cool to < 6°C within 24 hrs of collection	1 year	≤ –20°C
Mercury, total (Tissue)	0 to 6°C in dark	Cool to < 6°C within 24 hrs of collection	1 year	≤ –20°C
Mercury, total (Water)	0 to 6°C in dark	Preserve with 0.5% v:v pretested BrCl or 12N HCl within 48 hours of collection	90 days	Room temperature
Mercury, dissolved (Water)	0 to 6°C in dark	Filter and preserve with 0.5% v:v pretested BrCl or 12N HCl within 48 hours of collection	90 days	Room temperature
Methylmercury, total (Sediment)	≤ - 20°C	Freeze to ≤ –20 °C immediately	1 year	≤ - 20°C
Methylmercury, total (Water)	0 to 6°C in dark	Preserve with 0.5% v:v pretested 12N HCl within 48 hours	6 months	0 - 6°C in dark
Methylmercury, dissolved (Water)	0 to 6°C in dark	Filter as soon as possible after collection; preserve with 0.5% v:v pretested 12N HCl within 48 hours of collection	6 months	0 - 6°C in dark
Nitrate + Nitrite (Water)	4 ±2°C in dark	Cool to 4 ±2°C and reduce pH to <2 with H_2SO_4 within 48 hours of collection	28 day, if acidified	4 ±2°C in dark
Orthophosphate (Water)	4 ±2°C in dark	Filter within 15 minutes of collection; cool to 4 ± 2°C	48 hours	4 ±2°C in dark
TOC (Sediment)	0 to 6°C in dark	Freeze at the end of day	1 year	≤ –20°C

Parameter group	Storage (Collection to Extraction, where applicable)	Hold time (Collection to Extraction, where applicable)	Hold time (Extraction to analysis, where applicable)	Storage (Extraction to analysis, where applicable)
Total and Volatile Suspended Solids (Water)	4 ±2°C in dark	Cool to 4 ±2°C	7 days	4 ±2°C
Copper, dissolved	0 to 6°C in dark	Filter in the field as soon as possible after collection	180 days	0 - 6°C in dark
Pesticides—dissolved fraction*	0 to 6°C in dark	Extract within 48 hours of collection	Not to exceed 90 days	–20°C in dark
Pesticides—particulate fraction*	0 to 6°C in dark	Extract within 48 hours of collection	Not to exceed 180 days	–20°C in dark
Toxicity	0 to 6°C in dark	Initiate Test 36 h after sample collection	NA	NA

*Former versions of this document listed hold times of 30 days for pesticides. OCRL scientists have done studies to determine that the water samples are stable for up to 90 days (by eluting cartridges after varying amounts of time). For sediment/particulate, samples were found to be stable for up to 6 months if frozen (by analyzing the same sample after different amounts of storage time).

12.3 Trace Metals - Mercury

12.3.1 Sample Water

Sample containers will be labeled with the location, date, and time collected and packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets and chain-of-custody forms (COC) will be filled out at the time of collection and will include site code, site description, collection date/time, container type, sample preservation, field measurements, sampler(s) name, and requested analyses. All forms will be included with the appropriate samples during shipping. Samples will be delivered to MPSL in Moss Landing, CA. If upon arrival at the laboratory samples are found to be warm (ice melted), or if sample containers are broken, the Project Manager and Principal Investigator will be immediately notified. Ice chests are examined upon receipt to ensure that samples have been properly chilled (acceptable temperature range = 0° to 6° C).

Water samples will be delivered to MPSL within requisite holding times, where laboratory personnel will filter (if not field filtered) and preserve (if not field preserved) water samples following Table 12.1. Receipt temperature and sample condition (broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by receiving laboratories. Upon arrival of samples, appropriate laboratory processing forms noting unique laboratory ID, site name, collection time and date, receiving technician's name, requested analysis, and date and time of receipt will be filled out. Samples for dissolved mercury and dissolved methylmercury analysis will be filtered using 0.45-micrometer (μm) filters and acidified to 0.5% with pre-tested BrCl or 12N HCl as appropriate within 48 hours of collection.

12.3.2 Fish Tissue

Fish samples will be wrapped in aluminum foil and frozen on dry ice for transportation to the laboratory, where they will be stored at -20°C until dissection and homogenization. Lab homogenates will be frozen until analysis is performed. Frozen tissue samples have a 12-month hold time from the date of collection. If a hold-time violation has occurred, data will be flagged appropriately in the final results. Holding times for each analyte can be found in Table 12.1.

12.3.3 Sediment

Sediment samples will be preserved by the sample collection crew following Table 12.1. At the end of each collection event, samples will be delivered to MPSL.

12.4 Nutrients

Sample containers will be labeled with the location, date, and time collected and packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets and chain-of-custody forms (COC) will be filled out at the time of collection and will include site code, site description, collection date/time, container type, sample preservation, field water chemistry measurements, sampler(s) name and requested analyses.

Samples will be processed onboard, within 4 hours of collection. Samples for ammonium and nitrate + nitrite analysis will be acidified to a pH less than 2 with 2 mL of H_2SO_4 per L. Processed samples will be placed in a cooler on wet ice and shipped overnight to the USGS NWQL in Lakewood, CO. Receipt temperature and sample condition (e.g. broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by NWQL.

12.5 Conventional Water Quality Parameters

12.5.1 Chlorophyll

Samples for chlorophyll *a* analysis will be collected and field filtered using a syringe sample method and placed on dry ice until transfer to the lab. Samples will be filtered by forcing water with a 60-mL syringe through a filter holder containing a 25-mm glass microfiber filter. The 60-mL syringe and an inline filter holder are rinsed three times with the ambient water before filtration. The syringe is then filled with 60 mL of ambient water. The filter holder is then removed and a 25-mm glass microfiber filter is placed inside. The filter holder is then screwed onto the syringe and the ambient water is flushed through the filter. The filter holder is removed every time more water needs to be drawn into the syringe. The process is repeated until the desired amount of chlorophyll *a* is present (usually 60 to 360 mL depending on the water clarity). When filtering is complete, the filter holder is opened and the filter is removed with a forceps without touching the filtered material. The filter is then folded in half, then in quarters, with the chlorophyll *a* inside the folds. The folded filter is wrapped in aluminum foil

and placed in an envelope labeled with the site information and the volume filtered. The envelope will be immediately placed on dry ice until transferred to MPSL.

12.5.2 Dissolved Organic Carbon

DOC samples collected for nutrients monitoring program will be field filtered using a syringe sample method. Samples will be filtered into a 125-mL amber glass bottle pre-preserved with phosphoric acid by forcing water with a 60-mL syringe through a filter holder containing a 25-mm diameter 0.45-µm sterile membrane filter. Sample bottles should be filled only to the shoulder to ensure a final pH less than one.

12.5.3 Other Conventional Water Quality Parameters

TOC handling is covered in Section 12.1.3 Sediment. TSS/VSS have no special handling requirements and are covered in the second paragraph of Section 12.3.1, Sample Water on page 110.

13 Analytical Methods and Field Measurements

13.1 Field Measurements

The field collection teams will record measurements performed in the field on field sheets (electronic or paper), then enter them into a CEDEN template for subsequent entry in the Delta RMP database by SFEI-ASC. The master data logger is a Campbell Scientific CR6 (https://www.campbellsci.com/cr6). The data uploading is described in Section 19.3, Data storage/database on page 145.

13.1.1 Underway Flow-through Instrumentation and Data Collection System

Underway measurements will be made using a powered watercraft (USGS R/V Landsteiner) with a sample collection system connected to two sensors to measure nitrate concentration, conductivity, turbidity, pH, dissolved oxygen, fDOM, chlorophyll-*a*, and phycocyanin. Mapping data is collected at speeds up to 10 m/s. For details on operation of the flow-through system see Downing et al. (2016). The USGS National Field Manual for the Collection of Water-Quality Samples (https://water.usgs.gov/owq/FieldManual/index.html) provides additional SOP guidance.

Briefly, data is recorded at 1 Hz and displayed in real time so the boat operator may slow down when rapid changes in constituents occur. Boat position and time are logged using a GPS (Garmin 16X-HVS) and speed is maintained below 10 m/s. Care to avoid navigational hazards, like shallow water and submersible aquatic vegetation, is taken to prevent clogging in the pickup water tube or in the flow through system.

The watercraft will be outfitted with a sample pick-up tube, assembled from ¾ inch diameter PVC pipe, attached to the keel at the stern, fixed 0.5 m below the water surface. Tygon tubing will be used to direct flow from the pick-up tube to a 12 volt DC, Viton diaphragm pump (SHURflo, Cypress, CA) fitted with a 178 micron inline strainer (Cole Parmer; EW-29595-47). Oxygen de-bubblers will be used to prevent interference with optical measurements in the flow-through instrumentation system. Flow through instrumentation will be connected using Tygon tubing. All tubing will be new and, prior to use, all components of the flow-through system will be flushed with organic-free, deionized water.

The flow-through system will be divided into three flow paths after the pump. The first flowpath will be directed through a filter (Osmonics Memtrex, 25 cm length, 0.2 μm pore size; MNY921EGS; Osmonics, Inc.) and into a water sampler. The second flowpath will be directed into a 3-stage de-bubbler without filtration and then into a flow-through measurement system. The measurement system comprises a Seabird model SB45 thermosalinograph (conductivity and temperature), Satlantic model ISUS V3 nitrate analyzer (NO_3-N mg/L), and an YSI EXO2. The YSI EXO2 will be fitted with sensors measuring conductivity, turbidity, pH, dissolved oxygen, fDOM, chlorophyll-*a*, and phycocyanin. A third flowpath will be used to compensate for changes in system pressure resulting from changes in boat speed. All instrumentation will be cleaned and calibrated prior to each use. Calibration samples for nutrients and chlorophyll-*a* are collected throughout the day.

13.2 Laboratory Analysis

The following sections list the laboratory analytical methods that will be used in Delta RMP monitoring, and policies for sample archiving and disposal.

13.2.1 Analytical Methods

Table 13.1 provides a summary of analytical methods and instruments used by the Delta RMP.

Table 13.1 Summary of analytical methods and instruments.

Parameter group	Methods	Instrument
Nitrogen, ammonia	By colorimetry after reaction with salicylate-hypochlorite by measurement on an automated-segmented flow analyzer (Fishman 1993)	Segmented flow analyzer
Nitrogen, nitrate, and nitrite (Water)	Colorimetric determination following enzymatic reduction, and reaction with sulfanilamide and naphthyl ethylenediamine followed by measurement on an automated segmented flow analyzer (Patton and Kryskalla, 2011)	
Orthophosphate (Water)	By colorimetry after reaction with ammonium molybdate and reduction with ascorbic acid, then measurement on an automated-segmented flow analyzer (Fishman 1993)	

Parameter group	Methods	Instrument
Chlorophyll *a* (2 methods)	*In Vitro* determination by fluorescence (EPA 445.0) *In Vitro* determination by visible spectrophotometry (EPA 446.0)	Turner TD700 Genesis 10S
Mercury (Sediment, Tissue)	Thermal decomposition amalgamation and atomic absorption spectrophotometry (EPA 7473)	Milestone DMA80
Mercury (Water)	Oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (EPA 1631, Revision E)	Tekran 2600
Methylmercury (Sediment)	Potassium hydroxide/copper sulfate/methylene chloride extraction followed by aqueous ethylation, purge and trap, and cold vapor atomic fluorescence spectrometry (MPSL-110, EPA 1630)	Tekran 2700
Methylmercury (Water)	Distillation, aqueous ethylation, purge and trap, and cold vapor atomic fluorescence spectrometry (EPA 1630)	Tekran 2700
Pesticides	Gas Chromatography/ Mass Spectrometry (USGS TM-5-B1)	Agilent 7890 GC with a 5975 c mass spectrometer with a DB-5ms column (30 m × 0.25 mm ×
Pesticides	Liquid chromatography with tandem mass spectrometry (LC/MS/MS).	Agilent 1260 HPLC coupled to a 6430 tandem MS system with a Zorbax Eclipse XDB-C18 column (2.1 mm × 150 mm× 3.5 mm; Agilent).

All analytical method SOPs can be downloaded from the SFEI-ASC Google Drive. Appendix E provides a list and links to these SOPs.

Detailed descriptions of methods for analysis of pesticides can be found in these publications:

- *Delta Regional Monitoring Program Annual Monitoring Report for Fiscal Year 2015–16: Pesticides and Toxicity* (Jabusch, Trowbridge, Heberger, Orlando, et al. 2018)
- *Pesticide Inputs to the Sacramento-San Joaquin Delta, 2015-2016: Results from the Delta Regional Monitoring Program* (De Parsia et al. 2018)

13.2.2 Toxicity Testing Procedures

Staff of the Aquatic Health Program Laboratory (AHPL) at UC Davis shall perform aquatic toxicity testing following EPA methods, SWAMP MQOs, and the lab's SOPs as listed in Table 14.4 on page 133. Additional project-specific requirements are listed below for 3 test species.

Ceriodaphnia dubia

Toxicity testing according to SWAMP MQOs describes the recommendation for secondary conductivity controls when an ambient sample conductivity[20] is outside of the physiological range of the test organisms. These can be either high-conductivity controls (i.e., synthetic control waters salted up to match the highest conductivity of the ambient samples collected) or low-conductivity controls (i.e., synthetic control waters diluted with glass distilled water to match the lowest conductivity of the ambient samples collected). The latter will include nutrients (i.e., biotin, sodium selenate, and vitamin B_{12}) added to match the target concentrations in culture water. Secondary controls will be tested as outlined below and in Table 13.2.

Depending on the range of conductivities observed in ambient sample waters, additional negative controls may be tested to control for water quality near the organisms' tolerance threshold. Figure 13.1 on the following page is a flowchart showing how low-conductivity controls for *C. dubia* toxicity testing should be handled. Part (a) of the figure is a flowchart what controls the lab should prepare based on the range of conductivity in ambient samples. Part (b) is a flowchart showing which control each ambient sample should be compared to for performing a t-test which will result in a binary determination of "Is the ambient sample toxic? Yes/No."

SWAMP guidance states that for *C. dubia* toxicity testing, the sample conductivity should be above 100 µS/cm; although, previous Delta RMP testing found that *C. dubia* reproduction in AHPL cultures may be affected by conductivity as high as 127 µS/cm. Therefore, the lab shall run a tolerance control matching the lowest sample conductivity when there are sample(s) with conductivity ≤ 130 µS/cm. The laboratory will also have discretion to run a second tolerance control when there are multiple samples with conductivity ≤ 130 µS/cm (i.e., if samples with conductivity ≤ 130 µS/cm have a difference of at least 50 µS/cm).

[20] Conductivity refers to specific conductance (i.e., conductivity normalized to 25°C).

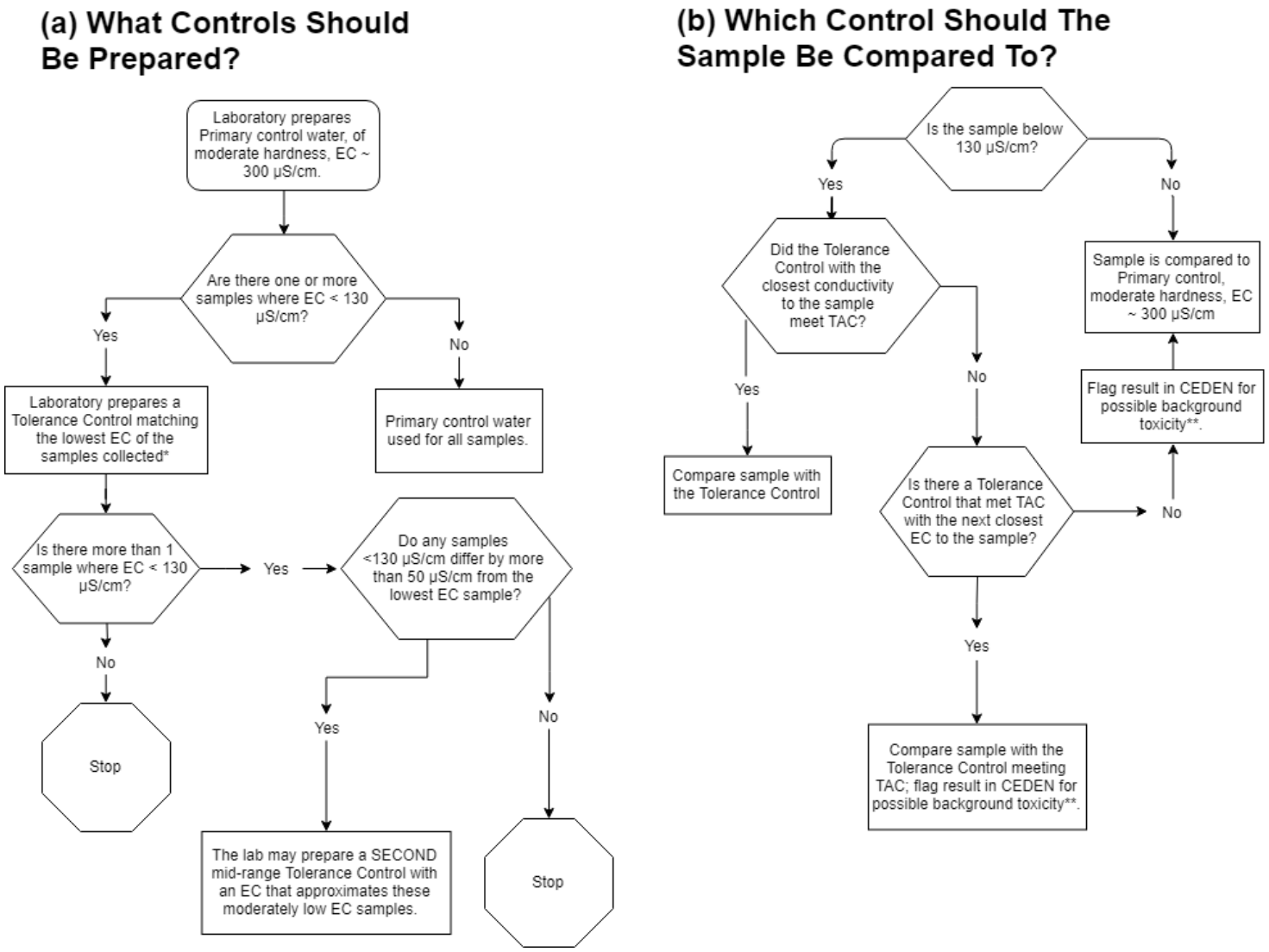

Figure 13.1 Flowchart illustrating procedure for handling low-conductivity controls for *C. dubia* toxicity testing.

When field crews take water samples, if the conductivity is less than≤ 130 µS/cm, they should ensure sufficient volume is collected for all testing and possible TIEs. (The AHPL lab manager has indicated that the planned volume is sufficient, but staff should continue to track this and adjust if necessary, for example, if larger volumes of water are required for TIEs.)

Ceriodaphnia dubia will not be tested in samples with specific conductance >2500 µS/cm, which is outside of the maximum tolerance of this test species. SWAMP MQOs state that *Hyalella azteca* can be used as a surrogate for *C. dubia* in this case. The Delta RMP is already testing with *H. azteca*.

The following describes additional testing for research purposes, with the intent of understanding if nutrient additions to low conductivity samples will increase *C. dubia* reproduction as AHPL has shown it does in the tolerance controls. One sample with conductivity ≤ 130 µS/cm in each batch will have an additional treatment tested where nutrients (i.e., biotin, sodium selenate, and vitamin B_{12}) added to match the amount added to the lowest SC tolerance control. The results of the research treatments will be compared to the secondary controls with most closely matching water quality and with the untreated sample to inform the Delta RMP if background water quality and/or nutrients affect the test organism response.

Hyalella azteca

Feeding during toxicity tests will follow the SCCWRP method where food is given two hours prior to water changes (Schiff and Greenstein 2016). This approach is consistent with SWAMP MQOs and reduces the potential for contaminants to sorb to food where they may be less bioavailable to the organism and bias the results.

Chironomus dilutus

Chronic toxicity testing is recommended by the CUP TAC to assess the potential for effects from imidacloprid and fipronil, to which the midge is sensitive. SWAMP MQOs for this 10-day chronic survival and growth test were published in August 2018 , and Delta RMP sample testing with midge will commence in the fall of 2018 as long as the laboratory has demonstrated proficiency in testing with this method, at the discretion of the SWAMP contract manager.

Any use of surrogate species must be approved by the SWAMP contract manager. Furthermore, it should be discussed by the Pesticides subcommittee of the Delta RMP TAC and approved by the Steering Committee. Alternative protocols can be proposed to SWAMP and EPA, but tests shall be run per the method for this project.

13.2.3 Sample Retesting

When a test fails to meet test acceptability criteria, the RMP project team may request a re-test. When a test fails to meet test acceptability criteria, the RMP project team may request a re-test.

Therefore, retesting samples may require using samples that have exceeded the 48-hour hold time. Decisions to retest samples need to be made as quickly as possible by the testing lab in consultation with the CUP Toxicity Subcommittee (see Appendix I). The laboratory will notify the CUP Toxicity Subcommittee by email of the possible need to retest immediately upon identifying an invalid test or, if possible, when the control is exhibiting a poor or irregular survival or reproduction pattern that causes the laboratory staff to anticipate that Test Acceptability Criteria may not be met. In this notification, the laboratory will describe the concern and could provide a recommendation for retesting or continued monitoring of the results.

Within 24 hours of test result notification from the toxicity laboratory, the CUP Toxicity Subcommittee will review the laboratory notification, discuss (i.e., over email or a conference call), and make a consensus decision regarding whether to retest a sample. The CVRWQCB SWAMP project manager or designee, who will be a part of the CUP Toxicity Subcommittee communications, will inform the laboratory of the decision on retesting. The laboratory will initiate the retest of the previously collected within 24 hours of notification from the subcommittee (i.e., within ~48 hours of the lab notification).

If the CUP Toxicity Subcommittee does not respond within 24 hours, then the laboratory will implement its recommendation. In the event that retesting is delayed beyond this timeline (e.g., organisms need to be ordered from a supplier or samples need to be recollected), such delays will be communicated to the CUP Toxicity Subcommittee and documented. Any issues contributing to an invalid test and the resolution will also be documented and submitted to the SWAMP QA Officer and to the Delta RMP program manager to inform adaptive management of the Delta RMP.

The potential need for resampling or retesting may also arise if, for example, samples are accidentally lost or destroyed in whole or in part. The bioassay laboratory will immediately notify the CUP Toxicity Subcommittee, SFEI/ASC TAC project manager, and the USGS analytical lab with a description of the problem so that a decision to resample can be made by the project team.

13.2.4 Statistical Analyses

Statistical analysis of laboratory toxicity test data will be consistent with standard single concentration statistical protocols (EPA, 2002; Appendix H). This approach compares each sample with the appropriate control and calculates the test result according to standardized statistical methods used in aquatic toxicology. Statistics for toxicity data will be made with the SWAMP Toxicity Transformer Excel sheets as provided by the SWAMP.

Samples will be compared with the appropriate negative control. This will be the negative control (i.e., primary or tolerance control) with water quality (i.e., specific conductance) most closely matching the sample when multiple negative controls are included as part of a toxicity

test. See Table 13.2 and the SWAMP 2018 Memo: "Use of Additional Controls in SWAMP Toxicity Tests."[21] Statistical analyses shall follow the method and SWAMP memo for additional controls. Specifically:

- Samples with conductivity > 130 µS/cm will be compared with the primary control.
    - If the primary control does not meet Test Acceptability Criteria then results are rejected. Retesting the sample and control can be considered.
- Samples with conductivity ≤ 130 µS/cm will be compared with the tolerance control. If there is more than one tolerance control then samples with ≤ 130 µS/cm will be compared with the tolerance control with water quality (i.e., conductivity) most closely matching the sample.
    - If the tolerance control with water quality (i.e., conductivity) most closely matching the sample does not meet Test Acceptability Criteria then either:
        - 1) Compare the sample with the other tolerance control if the other tolerance control meets Test Acceptability Criteria. Flag the result as potentially affected by background water quality effects.
        - 2) Compare the sample with the primary control if there was no other tolerance control that met Test Acceptability Criteria. Flag the result as potentially affected by background water quality effects.

A flowchart illustrating the steps above is shown in Figure 13.1 on page 116.

Sample comparisons with the primary control will generally determine toxicity due to contaminants in the sample when the sample is not outside or near the organisms' limit of tolerance. Likewise, comparing samples outside or near an organism's tolerance limit with the appropriate tolerance control accounts for possible background water quality effects to indicate effects due to contaminants. These comparisons will help answer the Delta RMP Assessment Question 1 (Status and Trends) "To what extend to current use pesticides contribute to observed toxicity in the Delta?" by identifying toxicity effects due to contaminants (e.g., pesticides).

When a tolerance control fails to meet test acceptability criteria it is an indication that the background water quality does not support the test organism and that the toxicity endpoint is not a reliable indicator of the effects due to contaminants in samples with similar water quality. Background water quality effects may be included in the observed effects when comparisons are made between a sample at or near an organism's tolerance limit and the primary control when the tolerance control fails to meet test acceptability criteria. This may describe the 'absolute toxicity' of a sample (i.e., difference between the sample performance and the maximum potential performance in its normal culture water conditions) but the result should be flagged as potentially affected by background water quality.

---

[21] https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/swamp_toxicity_test_control_water_memorandum.pdf

Lab analysts shall use the software application *Comprehensive Environmental Toxicity Information System*™ (CETIS; Tidepool Scientific, McKinleyville, CA, USA) to calculate Effect Concentration and Lethal Concentration values (EC_{25} for sublethal endpoints and LC_{50} for survival endpoints) for reference toxicant tests.

Table 13.2 Data analysis within each toxicity test batch

Sample Description	Control for Statistical Comparison	Batch	Outcome if Test Acceptability Criteria is not met by control
Samples with specific conductance closest to the primary control (i.e., culture water)	Primary Control	Primary Control	Primary Control batch results invalid; retest samples and Primary Control
Samples with specific conductance ≤130 µS/cm	≤130 µS/cm Tolerance Control with most similar water quality to the sample	≤130 µS/cm Tolerance Control	≤130 µS/cm Control batch results invalid; retest samples and ≤130 µS/cm Tolerance Control and/or compare sample with Primary Control (results will be flagged as potentially affected by background water quality).

Effects from background water quality at the edge of the organism tolerance range, where test organisms are not acclimated to conditions that differ from those in culture waters prior to the start of testing, can be best understood using secondary controls with similar water quality to control for background water quality effects. For the purposes of the Delta RMP, to identify the causes of effects due to pesticides (or other contaminants/not pesticides), comparison to a control that accounts for water quality effects will indicate the degree of effects due to contaminants and not due to background water quality. This is understood to be the absolute toxicity of the ambient sample.

Delta RMP samples will be compared with the control (either primary or secondary/tolerance control) with the most similar water quality conditions, measured by specific conductivity. This group or 'batch' will be analyzed independently of other batches (). If the negative control for a batch does not meet Test Acceptability Criteria, then the test organism health is compromised in those water quality conditions. There is not a valid benchmark for comparing the toxicity endpoint in samples associated with a negative control that does not meet Test Acceptability Criteria. Samples will be retested once. Sample results will remain invalid and not be reported if a batch control fails to meet Test Acceptability Criteria in a retest. The potential cause(s) of repeated control failures will then be investigated and corrective actions identified.

13.2.5 Toxicity Identification Evaluation (TIEs)

This section provides guidance for conducting Toxicity Identification Evaluations (TIEs). The trigger for a TIE shall be a ≥50% reduction in the organism response compared to the appropriate lab control. The decisions to perform TIEs will be made by the toxicity testing laboratory in consultation with a Delta RMP TIE subcommittee. Decisions to perform a TIE are event specific and dependent on the degree of effects observed in baseline testing, what is known about the sample (e.g., location, previous effects and toxicants, relevant pesticide applications), test species, and the available funding to conduct the TIE. The TIE Subcommittee and testing lab shall quickly decide whether to conduct TIEs, and whether to conduct any follow-up study (e.g., additional TIE treatments, supporting analytical chemistry).

This description is intended to be a starting point to inform the discussion and interpretation of any TIEs that are conducted on Delta RMP samples. TIEs may provide additional information that lead to other approaches to identify the cause of effects that are not identified here.

Phase 1 TIEs attempt to characterize the physical and chemical properties of the possible toxicant(s) in the sample. Information is gained regarding the physical/chemical properties of the toxicant(s) when the toxicity endpoint effect is reduced in a treated sample, adding to the weight of evidence regarding the class of contaminants that may have caused the toxicity. Phase 2 TIEs attempt to identify specific constituents causing or contributing to toxicity through chemical analyses or additional TIE treatments. Multiple TIE methods are presented in EPA guidance documents (USEPA 1991, 1992, 1993a, 1993b). Other approaches may be adopted from the peer-reviewed literature (e.g., Wheelock et al., 2004) or developed to address study-specific questions.

TIEs should be initiated as soon as possible (e.g., within 48 hrs) after exceeding the TIE trigger and following approval of the TIE Subcommittee. The laboratory must also conduct a preliminary validation of the initial toxicity test results by confirming that basic water quality parameters (e.g. conductivity, dissolved oxygen) were within acceptable ranges for the affected test species and that test acceptability criteria were met, unless sufficient acute effects provide clear direction on the need for retesting. Follow-up investigations (e.g., Phase 2 or 3 TIEs) may also be considered.

Delta RMP TIE testing has the primary goal of identifying whether pesticides are causing or contributing to observed toxic effects. A secondary goal may be to identify (or exclude) other factors (i.e., water quality conditions or other toxicants) contributing to reduced survival, growth, or reproduction. A phased TIE approach will be used, to the extent possible, to achieve these goals by initially focusing on treatments that identify major classes of contaminants that could include pesticides:

- EDTA (evidence of metals toxicity; minimum of 2 EDTA concentrations will be tested)

- Solid-phase extraction column (e.g., C-8 or C-18; evidence of toxicity due to non-polar organics, organic-metal chelates, and some surfactants)
- Centrifugation (evidence of toxicity due to particulate-bound contaminants such as chlorpyrifos and pyrethroids; use with turbid samples or at the discretion of the toxicity subcommittee)
- PBO (evidence of toxicity due to a substance that is metabolized by the CYP450 enzyme system; evidence of OP insecticides if toxicity is reduced and of pyrethroid insecticides if toxicity is potentiated)
- Carboxylesterase addition (evidence of toxicity due to a contaminant with an ester bond, such as pyrethroid insecticides)
- Baseline (confirms if the toxicity is persistent)

If the cause of an observed effect is not clear after initial TIE testing, or if further detail describing the type or specific toxicant is desired, then the CUP Toxicity Subcommittee may choose to have the laboratory conduct additional TIE treatments. Considerations for additional TIEs could include the level of available funding, magnitude of toxicity (TIE treatment effectiveness is easier to determine when there is a strong toxicity signal), species tested, and other data (e.g., potential sources, initial TIE results, and the likelihood that pesticides will be identified). As examples, the following TIE treatments could be selected to assess factors contributing to the observed effect:

- Low temperature – evidence of toxicity due to a contaminant that is metabolized, so lower temperatures slow the organisms' metabolism; increases the toxicity of pyrethroid insecticides
- Aeration – evidence of toxicity due to volatile, sublatable, or oxidizable compounds including surfactants
- Non-polar organic solid-phase extraction (SPE) column – evidence of toxicity due to a relatively polar organic contaminant
- pH 3/11 – evidence of toxicity due to hydrolysable/pH-dependent compounds (and filtration to assess/remove/control for settleable/coagulated toxicants and particulates).
- $Na_2S_2O_3$ – evidence of toxicity due to oxidants
- Cation Exchange – removes metals and other divalent cations
- Chemical analysis of cyanotoxins (to be compared with species-specific toxicity values). This would require freezing a subsample of the freshly collected sample for potential analysis if toxicity is observed from a location with known or potential cyanotoxin bloom.

The specific TIE treatments will depend on the test species described in **Table 1**. Salinity/conductivity is an important factor affecting toxicity test results for some species in the Delta, and TIEs in some samples with species sensitive to conductivity may require appropriate low-specific conductance or high-specific conductance secondary controls in addition to laboratory culture water controls treatments as indicated in SWAMP MQOs.

13.2.6 Sample Archive and Disposal

Project samples shall not be disposed of until all analyses are complete and analytical and QC results have been reviewed and approved by the SFEI-ASC Program Manager and the QAO.

14 Quality Control

14.1 Field Measurements

Prior to use in the field (typically within 24 hours prior to sampling), handheld water quality instruments are calibrated against appropriate standards and, if possible, checked against a standard from a different source. For some measurements such as dissolved oxygen, probes are often calibrated to ambient conditions rather than to known standards. In such cases, the field staff should verify appropriate qualitative instrument response (e.g., in water deoxygenated by sparging, sodium sulfite addition, or other means). All calibrations are documented on a calibration checklist on the individual instrument or its case with date, time, and operator name. If an instrument cannot be calibrated or is not reading correctly, a backup instrument will be used to measure water quality parameters.

For single or multi-parameter water quality meters, the following standards will be used to calibrate:

1. **pH** – commercially available standards pH 4, 7, 10. Perform a 2-point calibration covering the range of expected measurements. Use the 3rd pH standard (or standard supplied by another manufacturer) as a check standard to verify calibration accuracy.
2. **Specific Conductance** – perform a single-point calibration in the middle of the expected environmental range and use two check standards (KCl solution) bracketing the expected measurement range.
3. **Dissolved oxygen** – use calibration procedure recommended by manufacturer, typically in 100% air saturation.
4. **Temperature** – check against thermometer of known accuracy before each deployment. An ice water bath of approximately 0°C can be used to semi-quantitatively verify temperature probe response but may vary due to uncontrolled factors such as container size and geometry, ice/water disequilibrium, or the presence of melting point-lowering contaminants.

Flow-through instrumentation will be calibrated by applying temperature corrections to all fDOM, chlorophyll *a*, and phycocyanin measurements. Organic free DI water offsets will be collected and applied to optical nitrate measurements and fluorescence measurements (fDOM, chlorophyll *a*, and phycocyanin). All fDOM measurements will be corrected for turbidity interference and converted to quinine sulfate equivalents.

Data collected by the flow through system are inspected in real time and instruments are troubleshot in the field. If needed, calibration checks or standard curves are re-run in the field. Data are validated by comparing in situ field data with laboratory results. Correction factors can be applied when needed.

All instruments used with the flow-through system undergo blank and calibration checks as described in Table 14.1. The flow-through system makes redundant measurements (e.g. two chlorophyll fluorimeters, two fDOM fluorimeters, two thermistors), which allows technical staff to check constituent measurement accuracy throughout the day. Fouling and drift of instruments may occur due to electrical, optical, and/or communication issues, but redundant measurements can distinguish such issues, and/or environmental conditions. Additionally, grab samples are collected for laboratory analysis to ground-truth environmental measurements.

The Timberline ammonium analyzer requires a calibration curve at the start and end of each field day. The instrument is intermittently flushed with blank water and additional standards are run over the course of the field day. Repeat measurement will allow for confirmation of precision at calibration and in situ. Instrument measurements will be repeated a minimum of three (3) times, after the reading has stabilized, during every calibration or accuracy check event in the laboratory. Field measurements will be repeated a minimum of three (3) times only when conditions are not dynamically variable, after the reading has stabilized, while not in motion, at a minimum of two (2) sites per trip. Table 14.1 provides information on the performed QC checks and acceptable limits.

If failure of an instrument should occur, a backup instrument should be checked and calibrated. All sampling and measurement modifications or failures that occur in the field due to instrument malfunction will be recorded in the Field Form and the Field Reference Sheet. The Field Collection Coordinators, SFEI-ASC Program Manager, and the SFEI-ASC QAO will be responsible for ensuring that staff document all deviations from planned operations and schedule repairs and/or additional training as needed.

Table 14.1 Measurement quality objectives for field measurements.

Method	Parameters	QC check	Matrix	Frequency	Acceptable limits
Satlantic model ISUS V3, Nitrate analyzer	Nitrate	Calibration; range 0-70 µM	Water	Monthly calibration check (blank and standard curve) Blank check within 24 h before sampling Comparison to discrete grab samples (~1 sample collected every hour) analyzed by	Precision: Calibration to within 10% of nominal 2.5 µM S/N Accuracy/bias: Allowable drift ±10%

Method	Parameters	QC check	Matrix	Frequency	Acceptable limits
				standard laboratory methods.	
Seabird model 45 Thermo-salinograph WET Labs beam transmissometer (676 nm) YSI EXO 2	pH, SC, turbidity	Calibration	Water	Blank check within 24 h before sampling and at the end of the sampling event Calibration check within 24 h before sampling. Temperature check with NIST certified thermistor - every 6 months	Precision: Allowable performance (accuracy) ±10% for Specific Conductivity, ±0.2 for pH, ±5 turbidity units or ±5% of the measured value (whichever is greater) for turbidity Accuracy/bias: Drift from prior calibration ±10%
Timberline TL-2800 Analyzer	Ammonium	Calibration; range 0-70 µM	Water	Standard curve at start and end of sampling day. Blank water and standard checks intermittently (~ 1 per hour) throughout day	Precision: Calibration to within 10% of nominal 2.5 µM S/N Accuracy/bias: Allowable drift ±10%
WET Labs model WETStar cDOM fluorimeter	fDOM	Calibration in quinine sulfate	Water	Blank water check within 24 h before sampling. Intermittent functionality checks with fluorescent plastic test stick Calibration check within 24 h before sampling.	Precision ±10% Accuracy/bias: Drift from prior calibration ±10%
YSI EXO 2 Total Algae probe WET Labs model WETStar chlorophyll-*a* fluorimeter	Chlorophyll-*a*, phycocyanin	Calibration in with Rhodamine WT	Water	Calibration check within 24 h before sampling. Blank water check within 24 h before sampling. Intermittent functionality checks with fluorescent plastic test stick	Precision ±10% Accuracy/bias: Drift from prior calibration ±10%

14.2 Laboratory Analysis

The Laboratory Project Manager must demonstrate and document that the methods performance meets the data quality requirements of the project. Two separate factors are

involved in demonstrating method applicability: first, demonstrating that the laboratory can perform the method properly in a clean matrix with the analytical system under control, and second, demonstrating that the method selected generates "effective data" in the matrix of concern. The former addresses lab or operator training and proficiency, while the latter demonstrates that the selected method performs with the appropriate selectivity, sensitivity, accuracy, bias and precision, in the actual analytical matrix, to achieve project goals.

14.2.1 Measurement Quality Objectives

Laboratory Performance Measurements for Laboratory Analyses

Laboratory performance measurements are included in the QA data review to check if measurement quality objectives are met. Results of analyses of QC samples are to be reported with results of field samples. Minimum frequencies and target performance requirements for QC measures of reported analytes are specified in Table 14.2.

QC measures typically used for evaluation of laboratory and field sampling performance include the following:

7. **Method (or extraction/preparation) blanks**: samples of a clean or null (e.g., empty container) matrix taken through the entire analytical procedure, including preservatives, reagents, and equipment used in preparation and quantitation of analytes in samples.
8. **Field (or equipment/collection) blanks**: samples of a clean or null matrix taken through the sampling procedure, then analyzed much like an ordinary field sample.
9. **Surrogate standards**: analytes introduced to samples prior to sample extraction to monitor sample extraction method recoveries.
10. **Internal standards**: analytes introduced after the last sample-processing step prior to analysis, to measure and correct for losses and errors introduced during analysis, with recoveries and corrections to reported values generally reported for each sample individually.
11. **Matrix spike samples/duplicates**: field samples to which known amounts of target analytes are added, indicating potential analytical interferences present in field samples and errors or losses in analyses not accounted for by surrogate correction.
12. **Lab reference materials/laboratory control samples**: materials collected, bought, or created by a laboratory as internal reference samples, to track performance across batches.
13. **Instrument replicates**: replicate analyses of extracted material or standards that measure the instrumental precision.

14. **Laboratory replicates**: replicate sub-samples of field samples (preferred), standard reference materials, lab reference materials, matrix spike samples, or laboratory control samples, taken through the full analytical procedure including all lab processes combined.

Table 14.2 Measurement quality objectives for laboratory measurements

Method	Sample type	Matrix	Frequency	Acceptable limits
Conventional – Chlorophyll *a*				
EPA 445.0 or EPA 446.0	Calibration Verification	Water	Per 10 analytical runs	Recovery limit is ±20%; Expect 80% – 120% recovery
EPA 445.0 or EPA 446.0	Laboratory Blank	Water	1 per 20 or batch	< RL
EPA 445.0 or EPA 446.0	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample <RL
EPA 445.0 or EPA 446.0	Filter Blank	Water	Per method	<RL
EPA 445.0 or EPA 446.0	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
Conventional – DOC				
METH011.00 or TM-O-1122-92	Laboratory Blank	Water	1 per 20 or batch	< RL
METH011.00 or TM-O-1122-92	Matrix Spikes/Duplicates	Water	1 per 20 or batch	Expected value 20%; RPD < 25%
METH011.00 or TM-O-1122-92	Lab Duplicate	Water	1 per 20 or batch	RPD < 25%; n/a if concentration of either sample <RL
METH011.00 or TM-O-1122-92	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
Conventional – TOC				
EPA 440	Laboratory Blank	Sediment	1 per 20 or batch	< MDL
EPA 440	Matrix Spikes/Duplicates	Sediment	1 per 20 or batch	Expected value ±10%
EPA 440	Lab Duplicate	Sediment	1 per 20 or batch	RPD < 10%
EPA 440	Instrument Blank	Sediment	12 hours	<MDL
EPA 440	Field Duplicates	Sediment	Not less than 5% of all samples	RPD < 25%
EPA 440	Filter Blank	Sediment	1 per lot of filters or higher frequency	<MDL
Conventional – TSS, VSS				
SM 2540D or TWRI-5-A1	Laboratory Blank	Water	1 per 20 or batch	< RL
SM 2540D or TWRI-5-A1	Field Blank	Water	Not less than 5% of all samples	< RL

Method	Sample type	Matrix	Frequency	Acceptable limits
SM 2540D or TWRI-5-A1	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
Nutrients – Ammonium				
I-2525-89 or I-2522-90	Calibration Verification	Water	Per 10 analytical runs	Recovery limit is ±10%; Expect 90% – 110% recovery
I-2525-89 or I-2522-90	Laboratory Blank	Water	1 per 20 or batch, whichever is more frequent	< RL
I-2525-89 or I-2522-90	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample <RL
I-2525-89 or I-2522-90	Matrix Spikes/Duplicates	Water	1 per 20 or batch, whichever is more frequent	Expected value ±20%; RPD < 25% for duplicates
I-2525-89 or I-2522-90	Field Blank	Water	Per method	<RL
I-2525-89 or I-2522-90	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
Nutrients – Nitrate and Nitrite				
I-2545-90 or I-2546-91	Calibration Verification	Water	1 per 10 analytical runs	Recovery limit is ±10%; Expect 90% – 110% recovery
I-2545-90 or I-2546-91	Laboratory Blank	Water	1 per 20 or batch, whichever is more frequent	< RL
I-2545-90 or I-2546-91	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample <RL
I-2545-90 or I-2546-91	Matrix Spikes/Duplicates	Water	1 per 20 or batch, whichever is more frequent	Expected value ±20%; RPD < 25% for duplicates
I-2545-90 or I-2546-91	Field Blank	Water	Per method	<RL
I-2545-90 or I-2546-91	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
Nutrients – Orthophosphate				
I-2601-90 or I-2606-89	Calibration Verification	Water	1 per 10 analytical runs	Recovery limit is ±10%; Expect 90% – 110% recovery
I-2601-90 or I-2606-89	Laboratory Blank	Water	1 per 20 or batch, whichever is more frequent	< RL
I-2601-90 or I-2606-89	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample <RL
I-2601-90 or I-2606-89	Matrix Spikes/Duplicates	Water	1 per 20 or batch, whichever is more frequent	Expected value ±20%; RPD < 25% for duplicates

Method	Sample type	Matrix	Frequency	Acceptable limits
I-2601-90 or I-2606-89	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
Trace Metals – Mercury				
EPA 7473	Laboratory Blank	Sediment Tissue	1 per 20 or batch	< RL
EPA 7473	Matrix Spikes/Duplicates	Sediment Tissue	1 per 20 or batch	Expected value ±25%; n/a if concentration of either sample <RL
EPA 7473	Lab Duplicate	Sediment Tissue	1 per 20	RPD < 25%; n/a if concentration of either sample <RL
EPA 7473	Field Duplicate	Sediment	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample <RL
EPA 1631, Revision E	Laboratory Blank	Water	1 per 20 or batch.	< RL
EPA 1631, Revision E	Matrix Spikes/Duplicates	Water	1 per 20 or batch	Expected value ±25%; n/a if concentration of either sample <RL
EPA 1631, Revision E	Lab Duplicate	Water	1 per 20	RPD < 25%; n/a if concentration of either sample <RL
EPA 1631, Revision E	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%: n/a if concentration of either sample <RL
EPA 1631, Revision E	Field Blank	Water	Not less than 5% of all samples	<RL
Trace Metals – Mercury, Methyl				
MPSL-110	Laboratory Blank	Sediment	Per 20 samples or batch, whichever is more frequent	< RL
MPSL-110	LCS	Sediment	Per 20 samples or batch, whichever is more frequent	Expected value ±30%
MPSL-110	Matrix Spikes/Duplicates	Sediment	1 per 20 or batch	Expected value ±30%; RPD < 25% for duplicates; n/a if concentration of either sample <RL
MPSL-110	Lab Duplicate	Sediment	1 per 20	RPD < 25%; n/a if concentration of either sample <RL
MPSL-110	Field Duplicates	Sediment	Not less than 5% of all samples	RPD < 25%: n/a if concentration of either sample <RL
Trace Metals – Mercury, Methyl				

Method	Sample type	Matrix	Frequency	Acceptable limits
EPA 1630	Laboratory Blank	Water	1 per batch; for batches with over 20 samples: minimum of 1 per 20	< RL
EPA 1630	LCS	Water	1 per batch; for batches with over 20 samples: minimum of 1 per 20	Expected value ±30%
EPA 1630	Matrix Spikes/Duplicates	Water	1 per batch; for batches with over 20 samples: minimum of 1 per 20	Expected value ±30% RPD < 25% for duplicates; n/a if concentration of either sample <RL
EPA 1630	Lab Duplicate	Water	1 per batch; for batches with over 20 samples: minimum of 1 per 20	RPD < 25%; n/a if concentration of either sample <RL
EPA 1630	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%: n/a if concentration of either sample <RL
EPA 1630	Field Blank	Water	Not less than 5% of all samples	<RL
Pesticides				
USGS TM-5-C2	Calibration	Water	At each instrument set up, major disruption, and when routine calibration check exceeds specific control limits.	Linear regression, $R^2 > 0.995$ using a 7 point calibration curve ranging from 0.01 to 1 ng/uL
USGS TM-5-C2	Calibration Check	Water	Every 6 samples.	Recovery = 75 -125%
USGS TM-5-C2	Laboratory Blanks	Water	1 per 20 samples	< MDL
USGS TM-5-C2	Matrix Spikes/Duplicates	Water	1 per 20 samples	Recovery 70-130%, RPD < 25%
USGS TM-5-C2	Surrogate Spikes	Water	Every sample	Recovery = 70 -130%
USGS TM-5-C2	Internal Standards	Water	Every sample	Recovery = 70 -130%
USGS TM-5-C2	Field Blanks	Water	1 per 20 samples	< MDL
USGS TM-5-C2	Field Duplicate/ Replicate	Water	1 per 20 samples	RPD < 25%

Method	Sample type	Matrix	Frequency	Acceptable limits
USGS – SIR 2012-5026	Calibration	Water	At each instrument set up, major disruption, and when routine calibration check exceeds specific control limits.	Linear regression, r2 > 0.995 using an 7 point calibration curve ranging from 0.01 to 1 ng/uL
USGS – SIR 2012-5026	Calibration Check	Water	Every 6 samples.	Recovery = 75 -125%
USGS – SIR 2012-5026	Laboratory Blanks	Water	1 per 20 samples.	< MDL
USGS – SIR 2012-5026	Matrix Spikes/Duplicates	Water	1 per 20 samples	Recovery 70-130%, RPD < 25%
USGS – SIR 2012-5026	Surrogate Spikes	Water	Every sample	Recovery = 70 -130%
USGS – SIR 2012-5026	Internal Standards	Water	Every sample	Recovery = 70 -130%
USGS – SIR 2012-5026	Field Blanks	Water	1 per 20 samples	< MDL
USGS – SIR 2012-5026	Field Duplicate/ Replicate	Water	1 per 20 samples	RPD < 25%
Trace Metals – Copper (dissolved)				
USGS TM-5-B1	Laboratory Blank	Water	1 per 20 samples	< MDL
USGS TM-5-B1	CRM	Water	1 per 20 samples	Expected value +/- 25%
USGS TM-5-B1	Matrix Spikes/Duplicates	Water	1 per 20 samples	Expected value +/- 25%
USGS TM-5-B1	Lab Duplicate	Water	1 per 20 samples	RPD < 25%
USGS TM-5-B1	Instrument Blank	Water	Every 6 samples	<MDL
USGS TM-5-B1	Field Duplicates	Water	1 per 20 samples	RPD < 25%
Aquatic Toxicity Testing by AHPL				
Ceriodaphnia 7-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Hyalella 10-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Selenastrum (algae) 96-hr test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Chironomus (midge larvae) 10-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Pimephales (fathead minnow) 7-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%

MQOs for Aquatic Toxicity Testing

As shown in Table 14.2 above, the study design calls for a rate of field duplicates of 1 per 20 field samples. The field duplicate sample should be handled the same as for all other samples, and the full suite of toxicity tests should be run using all 5 species.

The water quality measurements specifically coupled to toxicity tests are intended to help interpret toxicity test data. Quality control practices and MQOs for toxicity testing and water quality measurements parallel those used for field meter instrumentation. Meters are calibrated at the beginning of each day and calibration checks are performed when measurements for the day exceed 20 readings for each meter. Meters are recalibrated when drift exceeds the MQO for accuracy in Table 14.3. Quality control samples are expected to fall within the precision MQOs below and data are qualified in instances when these are exceeded.

Table 14.3 Measurement quality objectives for toxicity testing in-test water quality measurements and field duplicates for toxicity testing laboratory analysis.

Parameter	Accuracy	Precision	Completeness
pH	± 0.2	± 0.5 pH units	90%
Specific Conductance	± 2%	± 10%	90%
Temperature	± 0.1	± 10%	90%
Dissolved Oxygen	± 0.2	± 10%	90%
Ammonia	± 0.5%	± 10%	90%
Hardness	Standard Reference Material (SRM) within 80 to 120% recovery	RPD < 25%	90%
Alkalinity	SRM within 80 to 120% recovery	RPD < 25%	90%
Toxicity Testing Field Duplicates	N/A	Statistical agreement between duplicates (RPD <25%)	90%

Table 14.4 Summary of toxicity methods and measurement quality objectives for aquatic toxicity testing.

Species	Test type	Duration	Endpoint(s)	CEDEN Code for Method	Method Name, Source	AHPL SOP	SWAMP MQOs
Fish - fathead minnow *Pimphales promelas*	Chronic	7 days	Survival, Biomass	EPA 821/R-02-013	Test Method 1000.0: Fathead minnow, *Pimephales promelas*, larval survival and growth test (EPA 2002)	AHPL SOP1-3	Table 9. 7-Day Chronic Freshwater *Pimephales promelas* Survival and Growth Toxicity Test
Invertebrate *Ceriodaphnia dubia*	Chronic	6-8 days	Survival, Reproduction	EPA 821/R-02-013	Test Method 1002.0: Daphnid, *Ceriodaphnia dubia*, survival and reproduction test (EPA 2002)	AHPL SOP1-2	Table 6. 6-8-Day Chronic Freshwater *Ceriodaphnia dubia* Survival and Reproduction Toxicity Test
Algae *Selenastrum capricornutum*	Chronic	4 days	Growth	EPA 821/R-02-013	Test Method 1003.0: Green alga, *Selenastrum capricornutum*, growth test (EPA 2002)	AHPL SOP 1-1	Table 10. 96-Hour Chronic Freshwater *Selenastrum capricornutum* Growth Toxicity Test
Invertebrate *Hyalella azteca*	Chronic	10 days	Survival	EPA/600/R-99/064	Test Method 100.1: *Hyalella azteca* 10-d Survival and Growth Test for Sediments (EPA 2000)	AHPL SOP1-6	Table 8. 10-Day Chronic Freshwater *Hyalella azteca* Survival and Growth Toxicity Test
Invertebrate – midge larvae *Chironomus dilutus*	Chronic	10 days	Survival, Growth	EPA/600/R-99/064	Test Method 100.2: *Chironomus tentans* 10-d Survival and Growth Test for Sediments EPA (2000)	AHPL SOP 1-11	Table 7. 10-Day Chronic Freshwater Chironomus dilutus Survival and Growth Toxicity Tesat

Notes on Table 14.4 (previous page)

EPA Methods are described in the following publications:

EPA. 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Fourth Edition. EPA/821/R-02/013. Office of Water, Washington, D.C. https://www.epa.gov/sites/production/files/2015-08/documents/short-term-chronic-freshwater-wet-manual_2002.pdf

EPA. 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates Second Edition. EPA 600/R-99/064. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30003SBA.TXT

Measurement Quality Objectives (MQOs) for toxicity testing are published by SWAMP and can be found in the following document

SWAMP. 2018. MQOs - Measurement Quality Objectives for Chronic Freshwater Toxicity Test Methods. https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/chronic_freshwater_tox_mqo_082218.pdf

Standard operating procedures describe the lab methods in detail and can be found in the documents here:

Aquatic Health Program Laboratory at UC Davis, Standard Operating Procedures (SOPs): - https://drive.google.com/drive/folders/1nLZfVlOQ19NUPoOwq5fCeIIJ7KtUnvg6?usp=sharing

14.2.2 Corrective Actions Procedures

If chemical analytical laboratory results fail to meet the MQOs, the corrective actions in Table 14.5 will be taken. Corrective actions will be documented, resolved, and followed-up on following the process for corrective actions that is outlined by the SWAMP. The process is based on the SWAMP Corrective Action Form and is applied to sample results that fail to meet the technical and non-technical requirements of SWAMP and its associated projects.

A description of corrective actions taken will be provided to the Delta RMP Technical Advisory Committee and other interested parties as a part of the QA Report accompanying the datasets produced in each focus area (mercury, pesticides, and nutrients).

Table 14.5 Corrective actions procedures for analytical laboratories.

If a problem is found with this laboratory QC sample type	The following corrective action(s) will be taken
Calibration Verification	Reanalyze the calibration verification to confirm the result. If the problem continues, halt analysis and investigate the source of the instrument drift. The analyst should determine if the instrument must be recalibrated before the analysis can continue. All of the samples not bracketed by acceptable calibration verification must be reanalyzed.
Matrix Spikes/Matrix Spike Duplicates	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike to confirm the result. Review the recovery obtained for the matrix spike duplicate. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Laboratory Blank	Reanalyze the blank to confirm the result. Investigate the source of contamination. If the source of the contamination is isolated to the sample preparation, the entire batch of samples, along with the new laboratory blanks and associated QC samples, should be re-prepared and/or re-extracted and analyzed. If the source of contamination is isolated to the analysis procedures, reanalyze the entire batch of samples. If reanalysis is not possible, the associated sample results must be flagged to indicate the potential presence of contamination.
Laboratory Duplicate	Reanalyze the duplicate samples to confirm the results. Visually inspect the samples to determine if a high RPD between the results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity.
Instrument Blank	Reanalyze the blank to confirm the result. Investigate, identify, and eliminate the source of contamination (e.g., instrument maintenance/cleaning and/or replacement of contaminated components). Analysis of samples shall be halted until contamination is eliminated.
LCS	If an LCS does not meet the acceptance criteria, there are usually problems with the laboratory method (e.g., imprecise aliquoting). Investigate, identify, and resolve the source of the bias. Samples need to be re-prepared and re-analyzed as samples with an acceptable LCS. If impossible, qualify reported data.

If a problem is found with this laboratory QC sample type	The following corrective action(s) will be taken
Field Duplicate	Visually inspect the samples to determine if a high RPD between results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Filter Blank	Investigate the source of contamination. Potential sources of contamination include sampling equipment, protocols, and handling. The laboratory should report evidence of field contamination as soon as possible, so that corrective actions can be implemented. Samples collected in the presence of field contamination should be flagged.

15 Instrument/Equipment Testing, Inspection, and Maintenance

15.1 Field Equipment

Field equipment such as boats, nets, and traps are inspected prior to each sampling event and are maintained throughout the field season and prior to storage during the off-season. Minimum equipment for the respective project elements includes:

Mercury - Fish

Boats (electro-fishing and/or for setting nets)

Bone saw, gill nets (various sizes), filet knives, fish picks, shackles, pliers, sharpening stone

Rod and reels, tackle box, landing net, live bait container

Plastic ice chests, inflatable buoy, floats, anchor chains, anchors, patch kit

Otter trawls

Blocks

Measuring boards, tape measure, id keys, Teflon cutting boards

Coolers

Mercury - Sediment

van Veen, Ekman, or Ponar grab sampler

Polycarbonate core tubes

Sampling scoops

Coolers

Mercury - Water

Collection devices appropriate for site

Field meters

Coolers

Nutrients

Flow-Through System

Pesticides and Aquatic Toxicity

Boat

collection devices

field meter

bottles

coolers and ice

Technical staff from the USGS Biogeochemistry group independently tests all mechanical and electrical components attached to instrumentation of the flow-through system for functionality prior to use in the field. Routine maintenance of boat motors and batteries is required to meet standards for safety. Instruments routinely require attention by the manufacturer (~1-3 years).

With the exception of the Timberline ammonium analyzer, the Biogeochemistry group keeps back-up instruments in house and has a network of researchers from whom they can borrow equipment when needed. Discrete samples for ammonium can provide redundancy and possibly a stand-in for environmental measurements made by the Timberline, should the instrument fail during field sampling.

Additional detail can be gleaned from TM9 (USGS Field Manual) and from Downing et al. (2016) and Fichot et al. (2015).

15.2 Laboratory Equipment and Supplies

Contract laboratories maintain equipment in accordance with their respective SOPs, which include those specified by the manufacturer and those specified by the method.

Laboratories maintain internal SOPs for inspection and quality checking of supplies. Under a performance-based measurement system approach, these procedures are presumed to be effective unless field and QC data from analyses indicate otherwise. SFEI-ASC will then work with the laboratory to identify the causes and address deficiencies in the SOPs that resulted in those problems. If the problem is serious and cannot be corrected by the laboratory, the SFEI-ASC Program Manager and QAO will discuss and identify alternatives, including changing the sampling materials and methods, the extraction and analytical methods, the laboratory, or any combination of these.

16 Instrument/Equipment Calibration and Frequency

16.1 Field Instruments/Equipment

Whenever an environmental water sample is collected, field crews shall collect basic water quality measurements using handheld measurement devices. Instruments for field data collection are described in Section 14.1, Field Measurements, on page 123.

16.2 Laboratory Equipment

Laboratories maintain calibration practices as part of their method SOPs. Calibration procedures are described generally below.

Upon initiation of an analytical run, after each major equipment disruption, and whenever on-going calibration checks do not meet recommended MQOs, the system will be calibrated with a full range of analytical standards. Immediately after this procedure, the initial calibration must be verified through the analysis of a standard obtained from a different source than the standards used to calibrate the instrumentation, prepared in an independent manner, and ideally having certified concentrations of target analytes (e.g., a certified solution). The calibration curve is acceptable if it has an r^2 of 0.995 or greater for all analytes present in the calibration mixtures. If not, the calibration standards, as well as all the samples in the batch, must be re-analyzed. All calibration standards will be traceable to an organization that is recognized for the preparation and certification of QA/QC materials (e.g., NIST, NRCC, U.S. EPA).

Calibration curves will be established for each analyte and batch analysis from a calibration blank and a multi-point calibration (as described or required in the method), covering the range of expected sample concentrations. Only data within the working calibration range (above the MDL) should be reported (i.e., extrapolation is not acceptable). Samples outside the calibration range will be diluted as appropriate and reanalyzed.

17 Inspection/Acceptance for Supplies and Consumables

17.1 Field Supplies

All containers should meet or exceed the required trace limits established by the U.S. EPA in the document EPA/540/R-93/051, Section 10, Specifications and Guidance for Contaminant-Free Sample Containers. Chemical-resistant powder-free nitrile and polyethylene gloves will be worn.

At a minimum, the following supplies are required for the respective project elements:

Mercury - Fish

- Waterproof labels
- Bait
- Heavy-duty aluminum foil (prepared), zipper-closure polyethylene bags
- Field sheet (see Appendix F)
- Ice
- Chain-of-custody form (see Appendix G)

Mercury - Sediment

- Sampling containers and labels
- Polycarbonate core tubes
- Nitrile gloves
- Wash bottles
- Field sheet (see Appendix F)
- Ice
- Chain-of-custody form (see Appendix G)

Mercury -Water

- Sampling containers and labels
- Powder-free nitrile gloves
- Deionized water squirt bottle
- Field sheet (see Appendix F)
- Ice
- Chain-of-custody form (see Appendix G)

Nutrients

- Flow-through system

Back up tubing, hose clamps, filter cases, pumps, and the like are brought to the field on each outing. Additional detail can be gleaned from TM9 (USGS Field Manual), Downing et al. (2016), and Fichot et al. (2015).

Pesticides and Toxicity Sampling

- Safety gear; personal flotation devices; wet-weather gear if necessary
- GPS unit; mobile phone and/or radio
- Sampling containers and labels
- Collection devices appropriate for site
- Powder-free nitrile gloves
- Field meters
- Deionized water squirt bottle
- Field sheet (see Appendix E)
- Coolers and ice
- Chain-of-custody forms (see Appendix F)

18 Non-direct Measurements

Non-Delta RMP data (e.g., from Irrigated Lands Regulatory Program) may be used in determining ranges of expected concentrations in field samples, characterizing average conditions (e.g., temperature, barometric pressure) for calculations, and other purposes. These data will be reviewed against the measurement quality objectives and used only if they meet all of the specified criteria (See Section 14.2.1, Measurement Quality Objectives, on page 126). Data not meeting Delta RMP quality objectives should be used only in a qualitative manner for developing conceptual models and prioritizing future data needs.

Hydrologic data (stage, flow, etc.) will be obtained from existing gauges and recorders located at or near designated monitoring locations. Only fully QA-reviewed hydrologic data will be used in analysis and reporting. Acceptable sources include the USGS National Water Information System (NWIS, https://waterdata.usgs.gov/nwis) and the DWR Water Data Library (WDL, http://wdl.water.ca.gov/waterdatalibrary/). Provisional data and modeled/forecasted data may be used for planning sampling events, for example determining whether there is sufficient rainfall and runoff forecasted to meet one of the event triggers described in Table 6.7 on page 62.

19 Data Management

This section provides a brief overview of how project staff manage data generated by the project's sampling and analysis. For more detailed information, refer to the Delta RMP Data Management and Quality Assurance Standard Operating Procedures document, included as Appendix H.

19.1 Entering and formatting of sampling and QA data results

19.1.1 Laboratory reporting of results

Chemical-analytical data shall be reported by labs in CEDEN's Water Quality (WQ) template. Tabulated data will include the following information for each sample (when applicable):

1. **Sample identification**: Unique sample ID, site code, site name, collection date, collection time, analysis date, sample type (field or QC types), and matrix.
2. **Analytical method**s: Preparation, extraction, and quantitation methods (codes should reference SOPs submitted with the data submission package). Also include preparation, extraction, and analysis dates.
3. **Analytical results**: Analyte name, fraction, result, unit, method detection limit (MDL), and reporting limit (RL) for all target parameters. The appropriate data qualifiers should be submitted with the results.
4. **Batch and result comments**: Lab comments must be applied to any batch when any QA code was applied to a result in the batch that may affect data use. A brief explanation of the issue shall be included.

Required additional data include:

- Lab replicate results (and field replicates, when sent for analysis)
- Quality assurance information for each analytical chemistry batch:
- CRM or LRM results: absolute concentrations measured, certified value, and percent recovery relative to certified or expected value.
- Matrix (or blank) spike results: include expected value (native + spike) for each analyte, actual recovered concentrations, calculated per recovery, and RPD.
- Method blank sample results in units equivalent to field sample results (e.g., if the field samples are reported as ng/g, method blanks are given in the same units). Lab replicate results and calculated RPD or RSD.

Documentation containing definitions, field length, field requirement, and associated lookup lists (if applicable) for each field is available on the CEDEN website (http://www.ceden.org/ceden_datatemplates.shtml). Fields requiring controlled vocabulary can be identified by hovering over the field name in the template and referring to the lookup list that is referenced. Lookup lists are available on the CEDEN website at http://www.ceden.org/CEDEN_Checker/Checker/LookUpLists.php.

Batches must be reviewed for QC completeness and any deviation in QC results should be documented in the accompanying case narrative. The required fields will be identified in the

template in green font. Each laboratory shall establish a system for detecting and reducing transcription and calculation errors prior to reporting data.

Only data that have met MQOs or that have deviations explained appropriately will be accepted from the laboratory. When QA requirements have not been met, the samples will be reanalyzed when possible. Only the results of the reanalysis should be submitted, provided they are acceptable.

Reporting turnaround times for submission of results from sample analyses are specified in contracts with the analytical laboratories. However, samples should be extracted and analyzed within the holding times specified for the analytical methods used (Table 12.1). Turnaround time requirements specified in subcontracts are generally 90 days or less.

19.1.2 Discrete water quality sampling data

The collection agencies and laboratories provide discrete data to SFEI-ASC in appropriate CEDEN templates (as provided by SFEI-ASC) within the timeframe stipulated in the contract, usually 90 days or less. The laboratories should use the current online data checker to review data for vocabulary and business rule violations prior to submitting to SFEI-ASC (contact DS@sfei.org for the current web address). SFEI-ASC will work with the labs to address vocabulary and business rule issues identified from using the data checker. SFEI-ASC will work with CEDEN to populate the lookup lists with new values as identified by the labs from using the online data checker.

The laboratories should report data as outlined in above in Section 19.1.1, Laboratory reporting of results, on page 141. Data are maintained at SFEI-ASC. SFEI-ASC tracks each data set, from submittal to final upload to the RDC database. Once all expected data have been received, expert staff on SFEI-ASC's Data Services team process the data using a series of queries designed to identify any issues remaining with the format of the data. The QA Officer or designee then reviews data for quality assurance and quality control and appropriate CEDEN QA codes are applied to the dataset.

Data that are approved for public release are made available through SFEI-ASC's Contaminant Data Display and Download tool (CD3), usually within one year of sample collection. Data will also be made available through CEDEN's Advanced Query tool. The contact individual for steps and tasks of data management is the SFEI-ASC data manager, Amy Franz.

SFEI-ASC maintains regular backups of their enterprise databases both to disk and tape, nightly and weekly, respectively. The RDC database, specifically, is also backed up hourly. As a further protective measure, copies of the tape sets are stored both onsite and offsite. The lifetime of the backup files on tape is about 2-3 weeks. Additionally, a backup of the RDC database from the first of every month is stored on disk indefinitely, allowing for quick restore and review of archived data as the need warrants.

19.1.3 Pesticides Chemistry Data

Pesticides chemistry is analyzed by the USGS Organic Chemistry Lab (OCRL) in Sacramento. The handling of these data is different from other Delta RMP datasets due to the nature of our cooperation with the USGS, which is not simply a contract lab, but a federal science agency with its own long-standing policies and procedures. According to USGS policy, results from their labs shall be included in the National Water Information System (NWIS). This is an online database where results are freely available to the public.

OCRL staff perform a quality assurance review of the results generated in their lab, and then upload provisional data to the NWIS database. Afterwards, OCRL transmits the data to ASC in the CEDEN data template format. ASC staff format these data and perform a thorough and independent QA review. As with other datasets, if serious issues arise, ASC will communicate with OCRL to resolve these issues. This would include, for example, missing or duplicate data, data that appear to have been reported incorrectly, results outside of the expected range, incorrect units, serious deviations from the measurement quality objectives, or any other issue identified that could indicate problems with the lab analysis.

As a part of ASC's QA review, the ASC QA Officer may flag records which did not meet MQOs, or reject results that are considered unacceptable. The QA officer writes a short memo summarizing the findings of the QA review, and summarizing the quality of the data. This memo describes whether the results received from the lab are complete and accurate and whether there is any evidence of contamination or other problems. The audience for the QA memo is both internal (the ASC project manager and staff) and external (stakeholders with an interest in reviewing the data and findings of the QA review).

The ASC project manager will distribute the provisional pesticides chemistry data and QA summary to the Delta RMP Technical Advisory Committee for review. ASC data analysts upload these data to CEDEN, and they are made viewable by the public once approved by the Delta RMP Steering Committee. Note that some stakeholders have suggested that this practice of withholding data pending SC approval is inappropriate and possibly illegal under California's open data laws. Staff and stakeholders will be reviewing this policy in 20019 and may suggest changes.

19.1.4 Underway flow-through measurements

Continuous field data collected by the USGS is immediately copied to multiple memory devices in the field upon completion of the measurements. The field data are uploaded to a secure USGS redundant network location upon return to the office that day or the following day. Quality assurance is performed by automated algorithms developed at USGS and checked by project technical staff. Temperature corrections and blank water offsets are applied to WET-Star (FDOM, Chl-a), YSI EXO total chlorophyll and fDOM probes, and nitrate instruments. WET-Star and EXO FDOM measurements are converted to quinine sulfate equivalents; turbidity and

inner filter effect corrections are applied when necessary. A twenty-second median is applied to all data. All values that fall outside of 3 standard deviations of the mean are removed. A thirty-second mean is calculated to reduce the size of the data files.

The USGS documentation for the data processing can be found in a technical report in the USGS Techniques and Methods series by Pellerin et al. (2013), and general guidance for field measurements and in the USGS *National Field Manual for the Collection of Water-Quality Data* (2015).

At present, the CEDEN database is not capable of storing high-frequency data such as collected by this project. Provisional field data will be made available to interested parties the week following collection. Final corrected data will be warehoused by the USGS and made available to interested parties upon request or via FTP. A final report will be prepared following data collection with a draft planned for spring 2019.

19.2 Laboratory data report package information

Analytical results, including associated quality control samples (see Section 14.2.1 Measurement Quality Objectives on page 126), will be provided to SFEI-ASC by the analytical laboratories. The laboratories analyze samples according to the hold times listed in the Delta RMP QAPP. The final report may be finalized for review up to 90 days after samples are received from the laboratory. Exceedances of the standard turnaround time should be discussed with and approved by the Delta RMP Program Manager and QAO.

Laboratory personnel will verify, screen, validate, and prepare all data, including QA/QC results, and will provide (upon request) detailed QA/QC documentation that can be referred to for an explanation of any factors affecting data quality or interpretation. Any detailed QA/QC data not submitted as part of the reporting package (see below) should be maintained in the laboratory's database for future reference.

Laboratories will provide electronic copies of the tabulated analytical data in a format agreed upon with the SFEI-ASC Program Manager, Data Manager, or a designee.

Results should be flagged by the laboratory for exceedances of Delta RMP MQOs for completeness, sensitivity, precision, and accuracy, using data quality codes as defined by CEDEN's list of QA codes, which have been adopted by the Delta RMP for reporting data. The data quality codes should be provided in the LabResult table in the ResQualCode and QACode fields. A list of commonly used result qualifier codes is shown in Table 23.1. The most commonly used QA codes are shown in Table 23.2. A complete list of codes is available online at CEDEN's Controlled Vocabulary web page, http://ceden.org/CEDEN_checker/Checker/LookUpLists.php.

For a detailed description of the measurements and procedures that are used by the lab QA Officer and ASC's QA Officer to demonstrate the quality of reported, see Section 7, Quality Objectives and Criteria, beginning on page 67.

19.3 Data storage/database

Data are managed by SFEI-ASC Data Services staff under the supervision of the Data Services Manager and the SFEI-ASC Quality Assurance Officer. Upon completion of QA/QC review and data validation, data are compiled into the SFEI-ASC RDC database and distributed to the project managers.

Data that are approved for public release are made available through SFEI-ASC's Contaminant Data Display and Download website (CD3, http://cd3.sfei.org/), usually within one year of sample collection. Data will also be made available through CEDEN's Advanced Query Tool webpage, https://ceden.waterboards.ca.gov/AdvancedQueryTool.

20 Assessment and Response Actions

Before a new monitoring project is initiated, an initial desktop or on-site performance audit will be performed by the QAO and designated staff to determine if each laboratory can meet the requirements of the QAPP and to assist the laboratory where needed. Additional audits may be conducted at any time during the scope of the study. The QAO will review every data file submitted as part of these audits and ensure that QC issues will be addressed as soon as they are detected. Results will be reviewed with participating laboratory staff and corrective action recommended and implemented, where necessary. Furthermore, laboratory performance will be assessed on a continual basis through laboratory intercomparison studies (round robins) where available, such as those conducted by the National Institute of Standards and Technology (NIST).

If data quality issues are identified, a preliminary meeting will be held between SFEI-ASC's QAO, the SFEI-ASC Program Manager, and the lab QAO to discuss possible solutions. If necessary, a corrective action plan will be developed in consultation with the appropriate lab(s), the corrective actions taken, and the issue and its resolution summarized in a brief report or memorandum. A summary of these issues will be maintained in the project files and will be noted in any reporting that includes affected data.

21 Reports to Management

The Implementing Entity of the Delta RMP (currently SFEI-ASC) will produce Annual Monitoring Reports for each of the focus areas, which documents the activities of the program each year; an interpretive main report (The *Pulse of The Delta*) that summarizes monitoring results and synthesizes the information they provide; and technical reports that document

specific studies and synthesize information from diverse sources in relation to specific topics and prioritized assessment questions. Reporting products and schedule are described in more detail in Section 6.6.

The Annual Monitoring Reports and/or QA Reports for each of the focus areas will present the results of the previous July-June fiscal year of sampling. The main purpose of these reports is to summarize the final data and results of the QA review. The QAO is responsible for summarizing potential QA issues with reported data and communicating those issues to the Program Manager. The QAO also reviews any SFEI-ASC analyses and reports generated from the data, to ensure that QA issues are appropriately acknowledged in the presentation and interpretation of data. The QAO will prepare a QA memo for each monitoring element (mercury, nutrients, etc.) annually, after completion of the QA review.

22 Data Review, Verification, and Validation

All Delta RMP data undergo review and evaluation to ensure that the data conform to quality criteria identified in this document and other project-specific criteria. In addition, data are assessed to determine usability and whether the data support their intended use. Review of the data consists of three discrete processes: verification, validation, and assessment.

22.1 Data Validation

Data are evaluated as meeting or failing MQOs, first by the laboratory, and again by the project QA Staff. In addition to contamination and other artifacts introduced by sampling and analytical methods, errors may arise at many points in the processing and transmittal of data generated for the Delta RMP. Characteristics of reported data are examined to identify possible problems in the generation and transmission of data.

Before submitting data, the contract laboratory's QA Officer (QAO) performs checks of all of its records and the laboratory's Director or Project Manager will recheck 10%. All checks by the laboratory may be reviewed by SFEI-ASC. Issues are noted in a narrative list and communicated to the field or laboratory teams as needed to correct any problems found (e.g. unanalyzed samples left in storage, transcription errors).

Data are submitted to SFEI-ASC in electronic form. After data are submitted and included in the Delta RMP database, SFEI-ASC staff examines the data set for completeness (e.g., correct numbers of samples and analyses, appropriate QC sample data included) and accuracy (e.g., in sample IDs), and spot-check for consistency with hardcopy results reported by the laboratory. The SFEI-ASC QAO or designee will examine submitted QA data for conformance with MQOs, specified previously (Section 14.2.1 on page 126). Data that are incomplete, inaccurate, or failing MQOs without appropriate explanation will be referred back to the laboratory for correction or clarification. The Project Manager and QAO will discuss data failing MQOs with laboratory

staff to determine corrective actions and whether the samples need to be re-collected. If problems cannot be readily corrected (insufficient sample, irremovable interferences, or blank contamination), results outside the MQOs will be flagged using CEDEN codes appropriate for the specific deviations to alert data users to uncertainties in quantitation. Results greatly outside the target MQO range (z-scores >2, e.g., for acceptance criteria of ±25%, >±50%) may be censored and not reported. The z-score is calculated as follows:

$$\mathrm{z-score} = \left|\frac{\text{result} - \text{expected value}}{acceptable\ deviation}\right|$$

23 Verification and Validation Methods

The QA/QC requirements presented in the preceding sections are intended to provide a common foundation for each laboratory's protocols; the resultant QC data will enable assessment of the comparability and uncertainty of results generated by different laboratories and analytical procedures. It should be noted that the QC requirements specified in this plan represent the minimum requirements for any given analytical method; labs are free to perform additional QC in accordance with their standard practices.

In addition to performance on required QC measures and samples (i.e., MDLs, blanks, matrix spikes, CRM, and replicates), data are also examined for internal and external consistency to ensure that reported values are realistic and representative for the locations and matrices of collected samples. This review may include but is not limited to:

5. Comparison of reported values to those from previous monitoring to evaluate if they are within the expected range of values for a given study. Simple statistics (e.g., minimum, maximum, mean, median) may be generated to quickly identify data sets or individual data points greatly outside of their expected range. Anomalous individual points will be examined for transcription errors. Unit conversions and sample quantitation calculations may be reviewed to identify larger and systematic errors. However, large differences from previously reported values may not necessarily indicate analytical issues and may simply reflect natural spatial and temporal variability of the ecosystem.
6. Comparison of reported values to those in the published literature, where available – differences from other regions and/or species may merely indicate differences in resident species and ecosystem structure, but very large (e.g. 2-3 orders of magnitude) differences may sometimes help identify errors in analysis or reporting (e.g. unit conversions).
7. Internal checks of relative analyte abundance. Variations in concentrations of one compound or isomer are often tightly linked to those of related compounds, such as its degradation products, manufacturing byproducts, or other compounds from the same group of chemicals (e.g., congeners of the same class of chemicals within a commercial

mixture). Deviations in these relative abundances can sometimes indicate matrix interferences or other analytical problems, although care should be taken to not disregard results that might reveal atypical sources and/or ecosystem processes.

Table 23.1 shows the CEDEN controlled vocabulary for result qualifiers. Table 23.2 shows the most frequently used CEDEN QA codes. A full list of QA codes that may be applied can be found online at CEDEN's Controlled Vocabulary web page.

When MQOs are not met, verification codes from the Batch Verification Look -up and/or QA Code Lookup tables may be applied by ASC staff or QA Officer and entered into the database. These codes are preceded by a "V" in the "Batch Verification Code" or "QA Code" fields. Individual records for field data and taxonomy, and laboratory batches for chemistry, tissue and toxicity will be coded "VAC" once verification is complete. This code is contained in the Batch Verification Code field. If deviations from the MQOs are detected by ASC staff that were not detected by the laboratory, the data is coded " VAC, VMD. " If some QC information is missing, the data will be coded with "VAC, VQI." If all QA data were expected to be reported and none are available, then the data are coded as "VQN ". When batches are determined to be missing some or all QC required information, ASC staff will initiate communication with the lab to obtain this information, and will recommend corrective action so this information is included in future data deliverables. When MQOs do not exist for certain data types, the data are coded as "NA" ("Not Applicable").

At the completion of the QA review by the QAO, results are assigned a compliance code on an individual record level. See Table 23.3 for compliance codes. Data are further assigned a batch verification code on a batch level. See Table 23.4 for batch verification codes. Results from the data review will be summarized in the annual QA Report.

Table 23.1 CEDEN controlled vocabulary for result qualifiers.

Result Qualifier Name	Result Qualifier Code
Absent	A
Colonial	COL
Confluent Growth	CG
Cw/C - Confluent Growth with Coliforms	w/C
Cw/oC - Confluent Growth without Coliforms	/oC
Detected Not Quantifiable	DNQ
Equal To	=
Field Estimated	JF
Greater Than	>
Greater than or equal to	>=
Less Than	<
Less than or equal to	<=
No Reportable Sum	NRS
No Reportable Total	NRT
No Surviving Individuals	NSI
Not Analyzed	NA
Not Detected	ND
Not Recorded	NR
Percent Recovery	PR
Present	P

Table 23.2 Common CEDEN QA codes.

QA Code	Description
BRK	No concentration sample container broken
BRKA	Sample container broken but analyzed
BS	Insufficient sample available to follow standard QC procedures
DO	Coelution
DS	Batch Quality Assurance data from another project
H	A holding time violation has occurred
IL	RPD exceeds laboratory control limit
IP	Analyte detected in field or lab generated blank
IU	Percent Recovery exceeds laboratory control limit
J	Estimated value - EPA Flag
M	A matrix effect is present
NBC	Value not blank corrected
None	None - No QA Qualifier
R	Data rejected - EPA Flag
SC	Surrogate Corrected Value
Other QA Codes	
BB	Sample > 4x spike concentration
BE	Low surrogate recovery; analyzed twice
BLM	Compound unidentified or below the RL due to overdilution
BT	Insufficient sample to perform the analysis
BY	Sample received at improper temperature
BZ	Sample preserved improperly
CS	QC criteria not met due to analyte concentration near RL
CT	QC criteria not met due to high level of analyte concentration
D	EPA Flag - Analytes analyzed at a secondary dilution
DRM	Spike amount less than 5X the MDL
EU	LCS is outside of acceptance limits. MS/MSD are accept., no corr.
EUM	LCS is outside of control limits

QA Code	Description
FO	Estimated maximum possible concentration (EMPC)
GN	Surrogate recovery is outside of control limits
GR	Internal standard recovery is outside method recovery limit
H24	Holding time was > 24 hours for Bacteria tests only
H6	Holding time was > 6 hrs but < 24 hours for Bacteria tests only
HH	Result exceeds linear range; concentration may be understated
HR	Post-digestion spike
HT	Analytical value calculated using results from associated tests
IF	Sample result is greater than reported value
JA	Analyte positively identified but quantitation is an estimate
LC	Laboratory Contamination
N	Tentatively Identified Compound
NC	Analyte concentration not certifiable in Certified Reference Material
NMDL	No Method Detection Limit reported from laboratory
NRL	No Reporting Limit reported by the laboratory
PG	Calibration verification outside control limits
PJ	Result from re-extract/re-anal to confirm original MS/MSD result
PJM	Result from re-extract/re-anal to confirm original result
QAX	When the native sample for the MS/MSD or DUP is not included in the batch reported
RE	Elevated reporting limits due to limited sample volume
SCR	Screening level analysis

Table 23.3 Compliance Codes.

DataCompliance Name	DataCompliance Code
Compliant	Com
Do Not Use	DNU
Estimated	Est
Historical	Hist
Not Applicable	NA
Not Recorded	NR
Pending QA review	Pend
Qualified	Qual
Qualified Historic	QualH
Rejected	Rej
Screening	Scr

Table 23.4 Batch verification codes.

BatchVerification Name	BatchVerification Code
Alternate Level Validation	VAP
Alternate Level Validation, Incomplete QC	VAP,VI
Alternate Level Validation, Incomplete QC, Flagged by QAO	VAP,VQI
Cursory Verification, Data Rejected - EPA Flag, Flagged by QAO	VAC,VR
Cursory Verification, Minor Deviations, Flagged by QAO	VAC,VMD
Cursory Verification, Minor Deviations, Incomplete QC, Flagged by QAO	VAC,VMD,VQI
Cursory Verification	VAC
Cursory Verification, Incomplete QC, Flagged by QAO	VAC,VQI
Cursory Verification/Validation	VLC
Cursory Verification/Validation, Incomplete QC, Flagged by QAO	VLC,VQI
Cursory Verification/Validation, Minor Deviations, Flagged by QAO	VLC,VMD
Cursory Verification/Validation, Minor Deviations, Incomplete QC, Flagged by QAO	VLC,VMD,VQI
Data Rejected - EPA Flag, Flagged by QAO	VR
Full Verification	VAF
Full Verification, Incomplete QC, Flagged by QAO	VAF,VQI
Full Verification, Minor Deviations, Flagged by QAO	VAF,VMD
Full Verification/Validation	VLF
Incomplete QC, Flagged by QAO	VQI
Incomplete QC, Temporary Verificaton, Flagged by QAO	VQI,VTC
Minor Deviations, Flagged by QAO	VMD
No QC, Flagged by QAO	VQN
Not Applicable	NA
Not Recorded	NR
Temporary Verification	VTC

24 Reconciliation with User Requirements

Measurement quality objectives listed previously (Section 14.2.1 on page 126) establish targets to be routinely achieved by the analytical laboratory. However, it is uncertain whether obtained data, even when meeting all stated MQOs, will be sufficient to answer the Delta RMP management questions with sufficient certainty, as the relative contributions of environmental variability and analytical uncertainty to cumulative uncertainty (e.g. for use in modeling, comparisons to guidelines, or other functions) cannot be known *a priori* before sufficient data have been collected. However, as Delta RMP studies proceed, the ability of collected data to answer these management questions should be periodically re-evaluated for study design and budget planning in subsequent years.

One of the goals of the initial phase of Delta RMP fish mercury monitoring is to obtain robust information on interannual variation to support future power analysis. The power to detect interannual trends in mercury in largemouth bass on a per site basis will be reevaluated when 3-5 years of monitoring data are available. It will be discussed then, whether the DQO needs to be refined and/or whether the monitoring design should be modified (e.g. increase or decrease the number of fish to be collected at each site).

The one-year nutrient monitoring project is similar to a proof-of-concept in terms of meeting DQOs. Assessing the statistical significance of spatial variation will depend on meeting the required performance criteria. There are currently no plans for additional underway flow-through measurement studies within the Delta RMP. Results from this study and their utility for answering management questions may inform future decisions about any future studies and any modifications that may be required.

25 References

California State Water Resources Control Board (SWRCB). 2017. *Quality Assurance Program Plan for the State of California's Surface Water Ambient Monitoring Program (SWAMP)*. https://www.waterboards.ca.gov/water_issues/programs/swamp/quality_assurance.html

California State Water Resources Control Board (SWRCB). 2017. *SWAMP Quality Assurance Program Plan (QAPrP)*. https://www.waterboards.ca.gov/water_issues/programs/swamp/quality_assurance.html#qaprp

California State Water Resources Control Board (SWRCB). 2018a. *Measurement Quality Objectives f or Chronic Freshwater Sediment Toxicity Test Methods*. https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/freshwater_sediment_tox_mqo_082218.pdf

California State Water Resources Control Board (SWRCB). 2018b. Toxicity Test Secondary Control Water Memorandum. https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/swamp_toxicity_test_control_water_memorandum.pdf

California State Water Resources Control Board (SWRCB). 2018. Updated Quality Control and Sample Handling Tables. http://www.waterboards.ca.gov/water_issues/programs/swamp/mqo.shtml

CEDEN. 2014. CEDEN - California Environmental Data Exchange Network. Data Templates Templates, and Documentation. Retrieved from http://www.ceden.org/ceden_datatemplates.shtml

Central Valley Regional Water Quality Control Board. 2006. *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Sacramento-San Joaquin Delta*. Central Valley Regional Water Quality Control Board. https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2006-0061.pdf.

Central Valley Regional Water Quality Control Board. 2011. 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 River Delta Estuary (Attachment 1 to Resolution No. R5-2010-0043). https://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/

Central Valley Regional Water Quality Control Board. 2014. *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Discharges*. Central Valley Regional Water Quality Control Board. https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2014-0041_res.pdf.

Central Valley Regional Water Quality Control Board. 2016. *Amendments to the 1994 Water Quality Control Plan for the Sacramento River and San Joaquin River Basins*. Central Valley Regional Water Quality Control Board. http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/2016july_1994_sacsjr_bpas.pdf.

Central Valley Regional Water Quality Control Board. 2017. *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Pyrethroid Pesticide Discharges*." Central Valley Regional Water Quality Control Board. https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2017-0057_res.pdf.

Central Valley Regional Water Quality Control Board. 2018. *The Water Quality Control Plan (Basin Plan) for the Sacramento and San Joaquin River Basins*. Fifth Edition. Central Valley Regional Water Quality Control Board. https://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/

De Parsia, M., J.L. Orlando, M.M. McWayne, and Michelle L. Hladik. 2018. "Pesticide Inputs to the Sacramento-San Joaquin Delta, 2015-2016: Results from the Delta Regional Monitoring Program." Data Series 1089. Sacramento, California: U. S. Geological Survey, California Water Science Center. https://pubs.er.usgs.gov/publication/ds1089

Downing, B.D., Bergamaschi, B.A, Kendall, C, Kraus, T.E.C, Dennis, K.J., Carter, J.A., Von Dessonneck, T.S. 2016. "Using continuous underway isotope measurements to map water residence time in hydrodynamically complex tidal environments." *Environmental Science & Technology* 50: 13387−13396. DOI: 10.1021/acs.est.6b05745

EPA. 2017, Aquatic Life Benchmarks and Ecological Risk Assessments for Registered Pesticides: U.S. Environmental Protection Agency website, accessed February 24, 2017, at https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/aquatic-life-benchmarks-pesticide-registration

EPA. 1991. *Methods for Aquatic Toxicity Identification Evaluations: Phase I Toxicity Characterization Procedures*. Second Edition. EPA 600/6-91/003. https://www.epa.gov/sites/production/files/2015-09/documents/owm0330.pdf

EPA. 1992. *Toxicity Identification Evaluation: Characterization of Chronically Toxic Effluents, Phase I*. Office of Research and Development, Duluth, MN. May 1992. EPA 600/6-91/005F. https://www.researchgate.net/publication/281593280_Toxicity_Identification_Evaluation_Characterization_of_Chronically_Toxic_Effluents_Phase_I

EPA. 1993a. *Methods for Aquatic Toxicity Identification Evaluations. Phase II Toxicity Identification Procedures for Samples Exhibiting Acute and Chronic Toxicity*. Office of Research and Development, Washington, D.C. September 1993. EPA 600/R-92/080. https://www.epa.gov/sites/production/files/2015-09/documents/owm0343.pdf

EPA. 1993b. *Methods for Aquatic Toxicity Identification Evaluations. Phase III Toxicity Confirmation Procedures for Samples Exhibiting Acute and Chronic Toxicity*. Office of Research and Development, Washington, D.C. September 1993. EPA 600/R-92/081.

EPA. 2000. *Water Quality Criteria for Priority Toxic Pollutants for California Inland Surface Waters, Enclosed Bays and Estuaries*. 40 CFR Part 131, U.S. Environmental Protection Agency. https://www.epa.gov/wqs-tech/water-quality-standards-establishment-numeric-criteria-priority-toxic-pollutants-state

EPA. 2002. *Guidance for Quality Assurance Project Plans* (QA/G-5), EPA/240/R-02/009. Washington, D.C. https://www.epa.gov/quality/guidance-quality-assurance-project-plans-epa-qag-5

EPA. 2002. *Short-term chronic methods for estimating chronic toxicity of effluents and receiving waters to freshwater organisms*. Fourth Edition. EPA-821-R-02-013. https://www.epa.gov/sites/production/files/2015-08/documents/short-term-chronic-freshwater-wet-manual_2002.pdf

Fichot, C.G., Downing, B.D., Bergamaschi, B.A., Windham-Myers, L., Marvin-DiPasquale, M., Thompson, D.R., Gierach, M. M. 2016. High-Resolution Remote Sensing of Water Quality in the San Francisco Bay-Delta Estuary. *Environmental Science & Technology*. 50 (2), 573-583. doi:10.1021/acs.est.5b03518.

Fishman, M.J., ed., 1993, *Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments*. U.S. Geological Survey Open-File Report 93-125, 217 p. http://nwql.usgs.gov/Public/rpt.shtml?OFR-93-125

Helsel, Dennis. 2010. "Much Ado About Next to Nothing: Incorporating Nondetects in Science." The Annals of Occupational Hygiene 54 (3): 257–62. https://doi.org/10.1093/annhyg/mep092.

Jabusch, Thomas, and Alicia Gilbreath. *Summary of Current Water Quality Monitoring Programs in the Delta*. Sacramento, California: Prepared for the Central Valley Regional Water Quality Control Board by the Aquatic Science Center, 2009. http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/studies_reports/drmp_wq_monitoring_progs_sum.pdf.

Jabusch, T., P. Trowbridge, M. Heberger, and M. Guerin. 2018. "Delta Regional Monitoring Program Nutrients Synthesis: Modeling to Assist Identification of Temporal and Spatial Data Gaps for Nutrient Monitoring." Richmond, California: San Francisco Estuary Institute – Aquatic Science Center. http://www.sfei.org/documents/delta-nutrients-modeling.

Jabusch, T., P. Trowbridge, M. Heberger, J. Orlando, M. De Parsia, and M. Stillway. 2018. "Delta Regional Monitoring Program Annual Monitoring Report for Fiscal Year 2015–16: Pesticides and Toxicity." Richmond, CA: Aquatic Science Center. http://www.sfei.org/documents/delta-pesticides-2016.

Keith, L.H. 1991. *Environmental Sampling and Analysis: A Practical Guide*. Lewis Publishers. Chelsea, MI.

Keith, L.H., Crummett, W., Deegan, J., Libby, R. A., Taylor, J.K. and Wentler, G. 1983. "Principles of Environmental Analysis." Analytical Chemistry 55(14): 2210-2218. https://pubs.acs.org/doi/abs/10.1021/ac00264a003?journalCode=ancham

Klasing, S. and R. Brodberg. 2008. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. California Office of Environmental Health Hazard Assessment, Sacramento, CA. https://oehha.ca.gov/fish/report/fish-contaminant-goals-and-advisory-tissue-levels-evaluating-methylmercury-chlordane

NDT Resource Center. 2016. *Accuracy, Error, Precision, and Uncertainty.* Iowa State University. https://www.nde-ed.org/GeneralResources/ErrorAnalysis/UncertaintyTerms.htm

Nowell, L.H., J.E. Norman, P.W. Moran, J.D. Martin, and W.W. Stone. 2014. "Pesticide Toxicity Index—A Tool for Assessing Potential Toxicity of Pesticide Mixtures to Freshwater Aquatic Organisms." *Science of the Total Environment* 476–477 (April): 144–57. https://doi.org/10.1016/j.scitotenv.2013.12.088.

Patton, C. J., and Kryskalla, J. R., 2011, Colorimetric determination of nitrate plus nitrite in water by enzymatic reduction, automated discrete analyzer methods." *U.S. Geological Survey Techniques and Methods*, Book 5, Chapter B8. https://pubs.er.usgs.gov/publication/tm5B8

Schiff, K. and D. Greenstein. 2016. *Stormwater Monitoring Coalition Toxicity Testing Laboratory Guidance Document*. Southern California Coastal Water Research Project (SCCWRP) Technical Report 956. December. http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/956_StrmWtrMonitCoalitToxTestingLabGuid.pdf

Stanley, T. W, and Verner, S. S. 1985. The U.S. Environmental Protection Agency's Quality Assurance Program. In: Taylor, J. K., and Stanley, T. W. (eds.) *Quality Assurance of Environmental Measurements*. ASTM STP 867. American Society for Testing and Materials. pp. 12-19.

Taylor, J. 1987. *Quality Assurance of Chemical Measurements*. Lewis Publishers. Chelsea, MI.

U.S. Geological Survey, variously dated, *National field manual for the collection of water-quality data (version 7)*: U.S. Geological Survey Techniques and Methods, book 9, chaps. A1–A10, accessed April 5, 2015, at http://water.usgs.gov/owq/FieldManual/.

Wheelock, C.E., J.L. Miller, M.J. Miller, S.J. Gee, G. Shan, and B.D. Hammock. 2004. "Development of Toxicity Identification Evaluation Procedures for Pyrethroid Detection using Esterase Activity. *Environmental Toxicology and Chemistry*, Vol. 23, No. 11, pp. 2699–2708. https://setac.onlinelibrary.wiley.com/doi/abs/10.1897/03-544

26 Appendices

26.1 Appendix A. Delta Regional Monitoring Program Participants

Participants	Participant Groups
Regulatory Agencies	Central Valley Regional Water Quality Control Board State Water Resources Control Board U.S. EPA Region 9 Water Division
Resource Agencies	NOAA Fisheries California Department of Fish and Wildlife
Coordinated Monitoring Programs	Interagency Ecological Program California Department of Fish and Wildlife California Department of Water Resources (DWR)
Wastewater Treatment Agencies	City of Bentwood City of Davis City of Rio Vista City of Sacramento City of Stockton City of Tracy City of Vacaville City of Woodland Ironhouse Wastewater Treatment Facility Lodi Water Pollution Control Facility Manteca Wastewater Quality Control Facility Mountain House Community Services District Regional San Town of Discovery Bay
Stormwater Agencies	California Department of Transportation City of Ceres City of Davis City of Hughson City of Lathrop City of Lodi City of Manteca City of Modesto City of Oakdale City of Patterson City of Rio Vista City of Ripon City of Riverbank City of Rocklin City of Stockton City of Tracy

	City of Turlock City of Vacaville City of West Sacramento City of Woodland Colusa County El Dorado County Sacramento County San Joaquin County Stanislaus County Sutter County Yolo County Yuba County
Irrigated Agriculture Coalitions	East San Joaquin Water Quality Coalition Sacramento Valley Water Quality Coalition San Joaquin County and Delta Water Quality Coalition Westside San Joaquin River Watershed Coalition
Dredgers	Army Corps of Engineers Port of Stockton Port of West Sacramento Sacramento Yacht Club
Flood Control and Habitat Restoration	California Department of Water Resources

26.2 Appendix B. Management Questions

Category	Management Questions
Status and Trends	Is there a problem or are there signs of a problem? a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?
Sources, Pathways, Loadings, and Processes	Which sources and processes are most important to understand and quantify? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?
Forecasting Water Quality Under Different Management Scenarios	a. How do ambient water quality conditions respond to different management scenarios? b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?

26.3 Appendix C. Assessment Questions

Delta RMP assessment questions for pesticides, mercury and nutrients. Questions in bold were identified by the Steering Committee as the highest priority in FY16/17.

Type	Core Management Questions	Mercury		Nutrients
Status & Trends	**Is there a problem or are there signs of a problem?** a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?	**1. What are the status and trends in ambient concentrations of total mercury and methylmercury (MeHg) in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large-scale restoration projects)?** **A. Are trends over time in MeHg in sport fish similar or different among Delta subareas?** B. **Are trends over time in MeHg in water similar or different among Delta subareas?**	**1. To what extent do pesticides contribute to observed toxicity in the Delta?** **1.1. Which pesticides or degradates have the highest potential to be causing toxicity in the Delta and therefore should be the priority for monitoring and management?** A. If samples are toxic, do detected pesticides explain the toxicity? B. If samples are not toxic, do detected pesticide concentrations exceed other thresholds of concern (e.g., water quality objectives or Office of Pesticide Programs aquatic toxicity benchmarks)? **1.2. What are the spatial and temporal extents of lethal and sublethal aquatic and sediment toxicity observed in the Delta?** A. Do aquatic or sediment toxicity tests at targeted sites indicate a toxic response? B. If answer to A is yes, which other toxicity indicator(s) should guide monitoring and management of pesticides in Years 2+? **2. What are the spatial/temporal distributions of concentrations of currently used pesticides identified as likely causes of observed toxicity?**	2. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally? A. Are trends similar or different across subregions of the Delta? B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? C. **Are there important data gaps associated with particular water bodies within the Delta subregions?** 3. **What is the current status of the Delta ecosystem as influenced by nutrients?** A. **What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?**

Type	Core Management Questions	Mercury		Nutrients
			2.1. Which pesticides have the highest risk potential (based on DPR's risk prioritization model[22]) and should be included in chemical analyses? A. Is the list of pesticides included in USGS pesticide scan sufficient for Delta RMP monitoring design? B. Are methods available to monitor pesticides with high-risk potential not included in USGS pesticide scan? 1. How do concentrations of the pesticides with the highest risk potential vary seasonally and spatially?	
Sources, Pathways, Loadings & Processes	Which sources and processes are most important to understand and quantify? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?	1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish? A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)? B. How do internal sources and processes influence methylmercury levels in fish in the Delta? C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels in fish in the Delta?	1. What are the principal sources and pathways responsible for aquatic and sediment toxicity observed in the Delta? 2. What are the fates of prioritized pesticides and degradates in the environment? 2.1. Do physical/chemical properties of priority pesticides, application rates and processes, and ambient conditions influence the degree of toxicity observed? **3. What are the spatial/temporal use patterns of priority pesticides?**	**4. Which sources, pathways, and processes contribute most to observed levels of nutrients?** A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters? B. What are the loads from tributaries to the Delta? C. **What are the sources and loads of nutrients within the Delta?** D. What role do internal sources play in influencing observed nutrient levels? E. Which factors in the Delta influence the effects of nutrients?

[22] http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/prioritization_report_2.pdf

Type	Core Management Questions	Mercury		Nutrients
				F. **What are the types and sources of nutrient sinks within the Delta?** G. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects?
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?	1. How do pesticide concentrations respond to different management scenarios? 2. What pesticide loads can the Delta assimilate without exceeding water quality criteria established to protect beneficial uses? 3. How will climate change affect concentrations and/or loadings of pesticides and impacts to aquatic species?	1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?	[none]	1. Are pesticide-related toxicity impacts decreasing over time?	[none]

26.4 Appendix D. Short Summaries of Delta RMP Monitoring Elements

26.4.1 Pesticides and Aquatic Toxicity

There will be six sampling events during the Water Year, with 24 samples per year at spatially distibuted sites and 6 samples per year at each of 2 fixed sites, for a total of 36 environmental samples, plus.

The timing of 3 sampling events is planned during Wet Weather to capture certain runoff and storm events: (1) first seasonal flush of the water year), (2) significant winter storm; (3) third winter storm. The remaining sampling events shall be during dry weather to caputre the irrigation/baseflow season: (4) spring, (5) summer, and (6) fall.

Chemical analyses and toxicity testing will be performed on all samples.

The Aquatic Health Program Laboratory at UC Davis will analyze the toxicity of water samples for a suite of test organisms based on EPA (2002, 2000) and SWAMP (2008) methods. Included Aquatic toxicity test species are, with endpoints in parentheses: (1) *Selenastrum capricornutum*, a single-celled algae (growth), (2) *Ceriodaphnia dubia*, a daphnid or water flea (survival, reproduction), (3) *Hyalella azteca*¸ an aquatic invertebrate (survival), (4) *Chironomus dilutus*, midge larvae (growth, survival), (5) *Pimephales promelas* (growth, survival). Pesticide-focused Toxicity Identification Evaluations (TIEs) for a subset of samples with $\geq$ 50% of the measured endpoint; to be decided real-time by a TIE subcommittee.

The following chemical analyses will be performed by the the USGS: current use pesticides (161 analytes), total suspended solids, dissolved organic carbon (DOC) and particulate organic carbon (POC), hardness, and dissolved copper.

26.4.2 Mercury

Sport Fish

Annual sampling at 7 fixed sites since 2016. Indicator of primary interest is methylmercury in muscle fillet of 350-mm largemouth bass (or similar predator species). Sites are located to represent different subareas of the Delta and to link with water monitoring.

Water

Sampling 8 sites that align with sport fish monitoring sites 10 times per year. Indicator of primary interest is total methylmercury in water.

Important ancillary parameters include total and dissolved total Hg and MeHg, chlorophyll *a*, DOC, suspended sediment concentrations, and volatile suspended solids.

Nutrients

A one-year study to document the variability of nutrients and related water quality parameters at high spatial resolution in the North Delta, Central Delta, and the Western Delta out to Suisun Bay. Measurements will include nitrate, ammonium, phosphate, temperature, conductivity, dissolved oxygen, chlorophyll, blue-green algal pigments, particle size and others. Data-collection cruises will be conducted under three different environmental/flow conditions (October 2017, May 2018, and August 2018).

26.5 Appendix E. List of SOPs

The following SOPs, manuals, and method reference documents will be made available on CD by request or can be downloaded from the SFEI-ASC Google Drive.

26.5.1 Field Sample Collection

USGS

- National Field Manual for the Collection of Water-Quality Data (USGS TM Book 9)
- Collection of Pyrethroids in Water and Sediment Matrices: Development and Validation of a Standard Operating Procedure
- Optical Techniques for the Determination of Nitrate in Environmental Waters: Guidelines for Instrument Selection, Operation, Deployment, Maintenance, Quality Assurance, and Data Reporting. (USGS TM Book 9)

MPSL

- MPSL Field SOP v1.1
- MPSL-101 Sample Container Preparation for Organics and Trace Metals, including Mercury and Methylmercury
- MPSL-102a Sampling Marine and Freshwater Bivalves, Fish and Crabs for Trace Metal and Synthetic Organic Analysis
- MPSL-102b Field Collection Procedures for Bed Sediment Samples
- Low level mercury (USGS NFM A5.6.4.B)
- Instructions for Constructing a Perforated Bucket Sampler to be Used as an Extended Holder for the Direct Filling of Sample Bottles (SWAMP SOP 2.1.1.4)
- MPSL-111 Field Collection Procedures for Depth Integrated Water via Bucket Sampler

26.5.2 Toxicity Testing

UCD-AHPL

- Initiation of *Selenastrum capricornutum* 96-Hour Chronic Toxicity Test (4th Edition) (SOP 1-1)
- Initiation of *Ceriodaphnia dubia* Chronic Toxicity Test (4th Edition) (SOP 1-2)
- Initiation of *Pimephales promelas* (Fathead Minnow) Chronic Toxicity Test (4th Edition) (SOP 1-3)
- Initiation of *Hyalella azteca* Acute 96-hour Water Column Toxicity Test (SOP 1-6)

- Initiation of *Chironomus dilutus* Chronic 10-day Water Column Toxicity Test (SOP 1-11)
- Protocol for Sample Receiving and Storage – Delta RMP Testing (SOP 12-7)

26.5.3 Toxicity Identification Evaluations (TIEs)

UCD-AHPL

- Protocol for Making a 5 ppm Solution of PBO and Spiking it into Sample Waters (SOP 7-1)
- C8 Solid Phase Extraction (SOP 7-2)
- C8 Column Elution for Phase I TIEs (SOP 7-3)
- C8 Column Elution for Phase II TIEs (SOP 7-4)
- Amendment of Water Samples with EDTA and Na_2S2O_3 (SOP 7-9)
- pH Adjustments to pH 3 and pH 11 (SOP 7-10)
- Aeration (Volatile/Surfactant Stripping) (SOP 7-11)

26.5.4 Toxicity Testing - Water Quality Measurements

UCD-AHPL

- Analysis for Total Water Hardness (SOP 6-1)
- Analysis for Ammonia Nitrogen (mg/L) (SOP 6-3)
- Analysis for Alkalinity (SOP 6-5)
- Use of YSI Model 33 Electrical Conductivity Meter (SOP 8-7)
- Operation of Beckman 12 pH/ISE Meter (SOP 8-8)
- Protocol for the YSI Model 58 Dissolved Oxygen Meter (SOP 8-9)

26.5.5 SWAMP Documentation

- SWAMP Toxicity Template Documentation
- SWAMP Toxicity Template
- SWAMP Sample Handling, Measurement Quality Objectives, and Corrective Action Tables

26.6 Appendix F. Example Field Sheets

Attach ASR and WatList

USGS science for a changing world

U. S. GEOLOGICAL SURVEY SURFACE-WATER QUALITY FIELD NOTES Station No. _____

NWIS Record No. _____

Station No. _____ Station Name _____ Field ID _____

Sample Date _____ Mean Sample Time _____ Time Datum _____ (eg. EST, EDT, UTC) End Date _____ End Time _____

*Sample Medium: WS WSQ OAQ *Sample Type: 9 (regular) 7 (replicate) 2 (blank) 1 (spike) _____

*see last page for additional codes

*Sample Purpose (71999): 10 (routine) 15 (NAWQA) 20 (NASQAN) 25 (NMN) 30 (Benchmark) _____

*Purpose of Site Visit (50280): 1001 (fixed-frequency SW) 1003 (extreme high flow SW) 1004 (extreme low flow SW) 1098 (NAWQA QC) _____

QC Samples Collected? Y N Blank Replicate Spike Other_____

Project No. _____ Project Name_____

Sampling Team _____ Team Lead Signature _____ Date _____

START TIME _____ GAGE HT _____ TIME _____ GHT _____ TIME _____ GHT _____ TIME _____ GHT _____ END TIME _____ GHT _____

FIELD MEASUREMENTS

Property	Parm Code	Method Code http://water.usgs.gov/usgs/owq/Forms/Fieldmeasurement_parametersmethods.doc	Result	Units	Remark Code	Value Qualifier	Null Value Qualifier	NWIS Result-Level Comments
Gage Height	00065			ft				
Discharge, instantaneous	00061			cfs				
Temperature, Air	00020	THM04 (Thermistor) THM05 (Thermometer)		˚C				
Temperature, Water	00010	THM01 (Thermistor)		˚C				
Specific Conductance	00095	SC001 (Contacting Sensor)		µS/cm				
Dissolved Oxygen	00300	LUMIN (Luminescent) MEMBR (Amperometric) SPC10 (Spectrophotometric)		mg/L				
Barometric Pressure	00025	BAROM (Barometer)		mm Hg				
pH	00400	PROBE (Electrode)		units				
Alkalinity, filtrd, incr. Alkalinity, filtrd, Gran	39086 29802	TT061 (Digital Titrator) TT062 (Buret) TT056 (Digital Titrator) TT057 (Buret)		mg/L				
Carbonate, filtrd, incr. Carbonate, filtrd, Gran	00452 63788	ASM01(Digital Titrator) ASM02(Buret) ASM03(Digital Titrator) ASM04(Buret)		mg/L				
Bicarbonate, filtrd, incr. Bicarbonate, filtrd, Gran	00453 63786	ASM01(Digital Titrator) ASM02(Buret) ASM03(Digital Titrator) ASM04(Buret)		mg/L				
Hydroxide, filtrd, incr. Hydroxide, filtrd, Gran	71834 29800	ASM01(Digital Titrator) ASM02(Buret) ASM03(Digital Titrator) ASM04(Buret)		mg/L				
Turbidity [see attachment for codes and units]								

SAMPLING INFORMATION

Parameter	Pcode	Value	Information
Sampler Type	84164	*see last page for proper codes— consider type of sampler and material*	Sampler ID:
Sampling Method	82398	10 EWI; 20 EDI; 30 single vertical; 40 multiple vertical; other _____	**BAG SAMPLER EFFICIENCY TEST**
Sampler bottle/bag material	84182	Plastic Bag (11) Teflon® Bag(12) Glass Bottle(20) Plastic Bottle (21) Teflon® Bottle (22) other (30)	Test / Duration Sampler Collected Water (seconds) / Sample Volume Collected (milliliters)
Sampler Nozzle material	72219	plastic (2) Teflon® (3) Brass (1)	1
Sampler Nozzle Diameter	72220	3/16" (3) 1/4" (4) 5/16" (5)	2
Sampler Transit Rate	50015	feet/second	3
Velocity to Calculate Isokinetic transit rate	72196	feet/second	Mean (72217) (72218)
Depth to Calculate Isokinetic transit rate	72195	feet	Bag Sampler Efficiency % *(See last page)*
Splitter Type	84171	*See last page for codes* _____	Splitter ID:
Hydrologic Condition	N/A	A Not Determined; 4 Stable, low stage; 5 Falling stage; 6 Stable, high stage; 7 Peak stage; 8 Rising stage; 9 Stable, normal stage	
Observations [Codes: 0=none; 1=mild; 2=moderate; 3=serious; 4=extreme]		Oil-grease (01300) ___ Detergent suds (01305) ___ Floating garbage (01320) ___ Floating algae mats (01325) ___ Floating debris (01345) ___ Turbidity (01350) ___ Atm. Odor (01330) ___ Fish kill (01340) ___ Gas Bubbles (01310) ___ Sewage Solids (01335) ___ Floating Vegetation (84178) ___ Ice Cover(01355) ___	

COMPILED BY: _____ **CHECKED BY:** _____ **LOGGED INTO NWIS BY:** _____

November 2013 1 SW Form version 9.0

SWAMP Tissue Sampling - Non-Trawl (Event Type = TI) **SWB_FishLk_LC_2014**					Entered in d-base (initial/date)		Pg of Pgs	
*StationCode: _ _ _ _ _ _ _ _ _ _	*StationName:					*Purpose Failure Code:	**Agency**	
*FundingCode: 1 3 S W B G 0 1	*Date (mm/dd/yyyy): / /							
Tissue Collection								
Location	*Depth (m):		Distance from Bank (m):		Accuracy (ft / m)	Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1					
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2					
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3					
HYDROMODLOC(to sample):	US / DS / NA / WI Other _____ Geoshape: Line Poly Point		Coord. 4					
Location	*Depth (m):		Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1					
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2					
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3					
HYDROMODLOC(to sample):	US / DS / NA / WI Other _____ Geoshape: Line Poly Point		Coord. 4					
Location	*Depth (m):		Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1					
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2					
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3					
HYDROMODLOC(to sample):	US / DS / NA / WI Other _____ Geoshape: Line Poly Point		Coord. 4					
Location	*Depth (m):		Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1					
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2					
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3					
HYDROMODLOC(to sample):	US / DS / NA / WI Other _____ Geoshape: Line Poly Point		Coord. 4					
Location	*Depth (m):		Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1					
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2					
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3					
HYDROMODLOC(to sample):	US / DS / NA / WI Other _____ Geoshape: Line Poly Point		Coord. 4					
Location	*Depth (m):		Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1					
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2					
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3					
HYDROMODLOC(to sample):	US / DS / NA / WI Other _____ Geoshape: Line Poly Point		Coord. 4					
Failure Codes: Dry (no water), Instrument Failure, No Access, Non-sampleable, Pre-abandoned, Other								
Comments:								

Modified 08/08/07

SWAMP Tissue Sampling - Non-Trawl (Event Type = TI) **SWB_FishLk_LC_2014** | Entered in d-base (initial/date) | Pg: of Pgs

*StationCode: __ __ __ __ __ __ __ __ __ __ | StationName: | Date (mm/dd/yyyy): / /

Location #	Organism ID	Tag #	Species Name/Code	FL (mm)	TL (mm)	StdL (mm)	Weight (g)	Count	Count Est.	Sex	Anomaly	Condition
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		

Location #: Match fish with Location # from Tissue Collection sheet | **Organism ID**: Combine composite # and fish # (e.g., fish 1 of composite WC01 is WC01-01) to be un | **Tag #**: Use if applicable

Species Code: Largemouth Bass **(LMB)**, Smallmouth Bass **(SMB)**, Spotted Bass **(SPB)**,Sacramento Pike Minnow **(SPM)**, Rainbow Trout **(RT)**, Brown Trout **(BT)**, Brook Trout **(BKT)**, White Catfish **(WC)**, Carp **(CAR)**, Channel Catfish **(CC)**, Brown Bullhead **(BRB)**, Sacramento Sucker **(SS)**, Redear **(RES)**, Black Crappie **(CRP)**, Bluegill **(BG)**, Tilapia **(TIL)**, Green Sunfish **(GRS)**, Kokanee **(KOK)**

Stage: Adult (A), Juvenile (J), Subadult (SA), Not Recorded (NR) | **Count Est**: If appropriate, add < or > if count is ¢

Anomalies: Ambicoloration (A), Albinism (B), Cloudiness (CL), Deformity-skeletal (D), Discoloration (DC), Depression (DS), Fin Erosion (F), Gill Erosion (T), Hemorrhage (H), Lesion (L), Parasite (P), Popeye (PE), Tumor (T), Ulceration (U), White Spots (W), and any combination | **Sex**:unk(U),taken at Lab(L) | **BodyLocation**: Branchial Chamber(BRC), Buccal Cavity(BC), Eyes(E), Musculoskeleton(M), Skin/Fins(SF)

Comments: Mark fish requiring further ID; **SEPARATE FISH BY LOCATION AND INDICATE LOCATION # ON LABEL**

Modified 06/19/07

26.7 Appendix G. Example for Chain of Custody Form

Results to:

CHAIN OF CUSTODY RECORD

Page of

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA, 94621-1424
Phone: 510-746-7334 Fax: 510-746-7300

Bill to:

Shipped to:

Sampled by [Print Name(s)] / Affiliation

Sampler(s) Signature(s)

Preservatives (see codes)

Analyses Requested

Project Name:

Sample ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number/Size/Type of Containers	Remarks

Shipment Method

Out: / / Via:

← Total Number of Containers

Relinquished by / Affiliation	Date	Time	Accepted by / Affiliation	Date	Time

Additional Comments:

Cooler No.(s) / Temperature(s) (C)°

MATRIX CODES: F = Freshwater S = Saline SE = Sediment SW = Surface Water PW = Porewater B = Blanks T= Toxicity O = Other (specify)

PRESERVATIVE CODES: H = Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

26.8 Appendix H Delta RMP Data Management and Quality Assurance Standard Operating Procedures

Link to SOP document

26.9 Appendix I: TIE Communication Protocol

The CUP Toxicity Subcommittee with be notified by the laboratory via email on the day an observation is made that a sample (or samples) exceeds the TIE trigger. Specific TIE treatments will follow those in Table 26.1 unless the laboratory recommends alternative procedures, or the CUP Toxicity Subcommittee makes alternative decisions. Direction from the CUP Toxicity Subcommittee to the laboratory will also be communicated exclusively through the CVRWQCB SWAMP contract manager. In addition, the SWAMP QA Officer will be cc'ed on email communications or otherwise kept informed by the program manager.

Notification from the laboratory will provide preliminary results of the associated control(s) and affected sample(s), identify the species affected, and preliminary confirmation of the test validity (e.g., Test Acceptability Criteria met; water quality parameters were within the acceptable range). The availability of laboratory resources and possible timing for conducting additional testing will also be communicated to the CUP Toxicity Subcommittee so that any potential scheduling issues can be considered in TIE decisions (e.g., delays for ordering test supplies, organisms, or days when tests can/cannot be started).

Within 24 hours of test result notification from the laboratory, the CUP Toxicity Subcommittee will review the laboratory results, discuss (i.e., over email or a conference call), and make a consensus decision regarding whether and how to proceed with a TIE. The CUP Toxicity Subcommittee will approve TIEs based on the degree of effect, available funding, chemical data, and other available information (e.g., pesticide application reports).

The CVRWQCB SWAMP contract manager will then inform the laboratory of the Delta RMP toxicity subcommittee's decision. TIEs will be initiated by the laboratory within 24 hours of notification (i.e., within ~48 hours of the observation of a TIE trigger exceedance).

It is critical to make decisions and start any testing as soon as possible to minimize the potential loss of a toxicity signal (e.g., due to sorption to sample containers, degradation, or transformations) and every attempt will be made to minimize the time between sampling and testing. However, extenuating circumstances may delay TIE initiation beyond these goals (e.g., organisms need to be ordered from a supplier). These delays will be communicated to the CUP Toxicity Subcommittee and documented so that corrective actions/alternative planning can be considered for the next sampling event.

Decisions and their rationale will be documented to justify the intended objective and benefits of any additional use of resources. Issues and their resolution will also be documented to inform decisions for future TIE testing if the issue arises again (i.e., by providing the information indicated in Table 26.2).

The toxicity testing laboratory will proceed with the default course of action according to the decision flowchart (Figure 26.1) in the absence of clear direction from the CUP Toxicity Subcommittee (e.g., if none of the subcommittee members are available).

The Delta RMP CUP Toxicity Subcommittee consists of the following TAC members:

- Cameron Irvine (Robertson-Bryan, Inc.) – TAC alternate for waste water dischargers
- Stephen Clark (Pacific EcoRisk Laboratory) – Representing agriculture
- Melissa Turner (MLJ Environmental) - TAC member for agriculture

Other collaborators who will be involved in discussion of toxicity and TIEs include:

- Marie Stillway (AHPL) – Laboratory Manager; conduct toxicity tests and TIEs
- Alisha Wenzel (Central Valley Regional Water Quality Control Board) – SWAMP/ Regional Project Manager (may identify a designee)
- Matt Heberger (SFEI-ASC) – Delta RMP Program manager, Liaison to the Delta RMP TAC
- Stephen McCord – Delta RMP TAC chair
- Jim Orlando (USGS) – Laboratory Manager; conduct chemical analyses of surface water samples; report preliminary results to the CUP Toxicity Subcommittee upon request
- Bryn Phillips (UC Davis Granite Canyon Laboratory) – SWAMP Toxicity Work Group
- Stephen Louie (California Department of Fish and Wildlife)

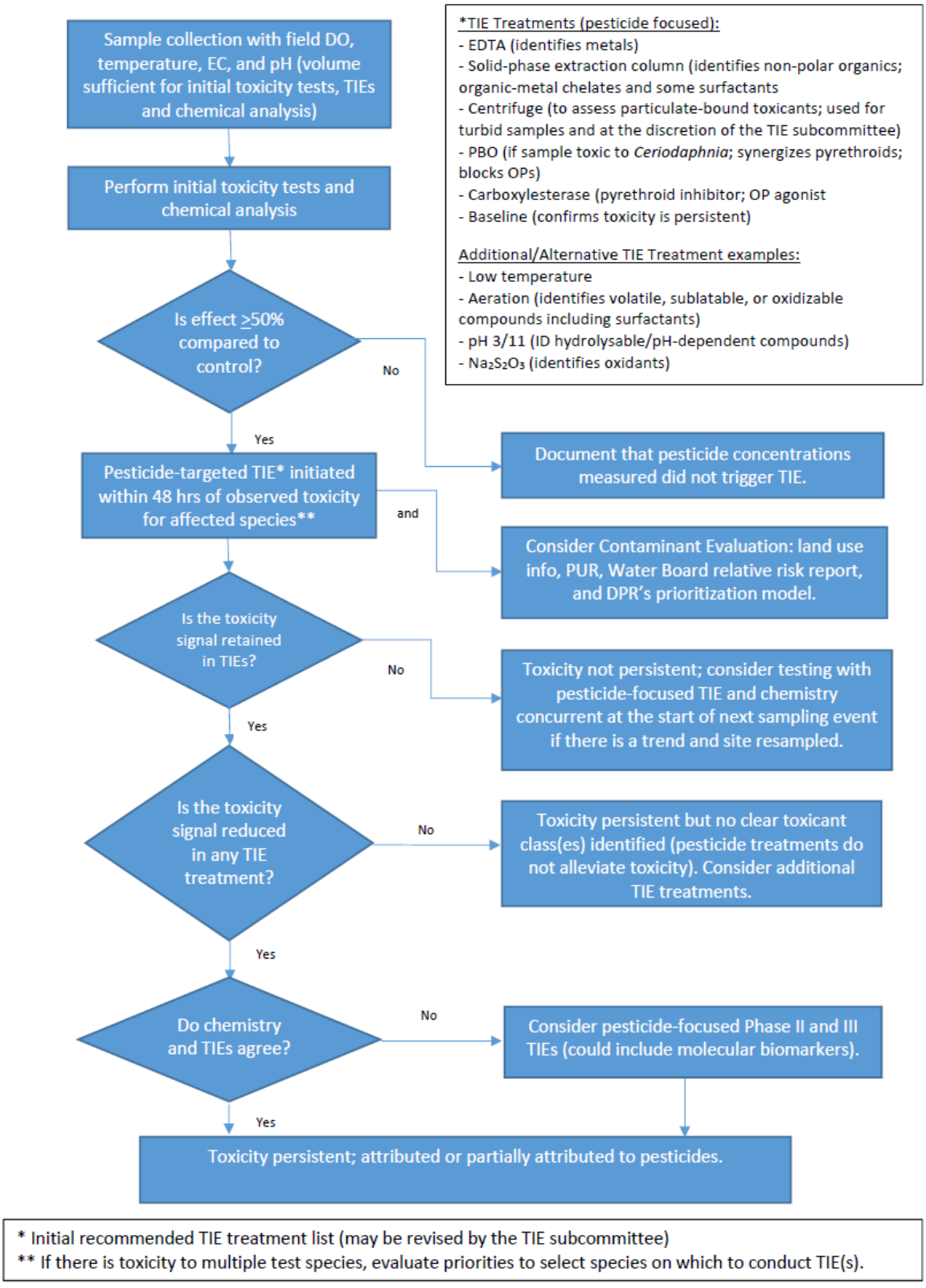

Figure 26.1 Flowchart illustrating decision-making process for initiating TIEs.

Table 26.1 Summary of species-specific Phase 1 TIE treatments

TIE Treatment	*H. azteca* (n = 18)	*C. dilutus* (n=9)	*C. dubia* (n=20)	Algae (n=7)	Fish (n=11)
Baseline	Laboratory Control	Laboratory Control	Laboratory Control	Laboratory Control	Laboratory Control
	Ambient Sample	Ambient Sample	Ambient Sample	Ambient Sample1	Ambient Sample
	Secondary Control (If needed)		Secondary Control (If needed)		Secondary Control (If needed)
	HAC		HAC		HAC
Cation Exchange – removes metals and other divalent cations	Ambient Sample + Chelex	Ambient Sample + 3 mg/L EDTA2	Ambient Sample + 3 mg/L EDTA2	Ambient Water - Chelex 100 Sodium Form (for divalent cations)2	Ambient Sample + 3 mg/L EDTA2
	Chelex blank	Ambient Sample + 8 mg/L EDTA2	Ambient Sample + 8 mg/L EDTA2	Control Water Blank for Chelex 100 Sodium Form	Ambient Sample + 8 mg/L EDTA2
			HAC + 8 mg/L EDTA2	-	HAC + 8 mg/L EDTA2
Piperonyl Butoxide (PBO) - increases pyrethroid toxicity and decreases organophosphate pesticide toxicity	Ambient Sample + 100 ppb PBO (chronic and acute tests)	N/A	Ambient Sample + 100 ppb PBO (chronic and acute tests)	N/A	N/A
	Ambient Sample + 25 ppb PBO (chronic test)		Ambient Sample + 25 ppb PBO (chronic test)		
			HAC + 100 ppb PBO (chronic and acute tests)		
Temperature adjustment	HAC 15ºC (if needed)				
	Ambient Sample 15ºC				
BSA	Ambient Sample + BSA	N/A	Ambient Sample + BSA	N/A	N/A
	HAC + BSA blank		HAC + BSA		
Carboxylesterase (CO) – reduces toxicity from organophosphate pesticides	Ambient Sample + CO	N/A	Ambient Sample + CO	N/A	N/A
	HAC + CO blank		HAC + CO		

TIE Treatment	*H. azteca* (n = 18)	*C. dilutus* (n=9)	*C. dubia* (n=20)	Algae (n=7)	Fish (n=11)
Solid-Phase Extraction (SPE) - removes non-polar organics	Ambient Sample + C8 SPE	Ambient Sample + C8 SPE	Ambient Sample + C8 SPE	Ambient Sample + SM2 SPE	Ambient Sample + C8 SPE
	HAC + C8 blank	C8 blank	C8 blank	C8 blank	C8 blank
	HAC + MeOH @ 0.5% (blank)	MeOH @ 0.5%	HAC + C8 Blank	Control Water + SM2 SPE	HAC + C8 Blank
	HAC + Eluate addback @ 3x	Eluate addback @ 3x	HAC + MeOH @ 0.5%	-	HAC + MeOH @ 0.5%
	-		HAC + Eluate addback @ 3x	-	HAC + Eluate addback @ 3x
Centrifuge – removes particulate associated toxicity	Ambient Sample Centrifuged	Ambient Sample Centrifuged	Ambient Sample Centrifuged	N/A	N/A
	HAC Centrifuged		HAC Centrifuged		

Table Notes:

Treatment Details are provided in Appendix A

HAC - Hardness adjusted controls

LEC – low EC control (if sample specific conductance is at/near the species tolerance)

N/A – not applicable

[1] Salinity can affect test; monitor and consider ion imbalance at >2ppt)

[2] Cation exchange resin may change after AHPL can validate options (e.g., chelex or Suppelco column) for these tests.

Table 26.2 Delta RMP pesticide TIE issue resolutions and lessons learned example table

Sample Affected	Issue	Resolution
Provide the sample location, date, test species and endpoint affected	Describe the question/issue discussed or lesson learned	Describe the resolution, corrective action, lesson learned, or what additional information might be needed