Delta Regional Monitoring Program

Quality Assurance Program Plan

Version 3.5
revised March 14, 2018

Prepared by
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SFEI | AQUATIC SCIENCE CENTER

1 Title and Approval

For

PROJECT NAME: Delta Regional Monitoring Program

Date: February 16, 2018

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

Approval Signatures

Title:	Name:	Signature:	Signature Date:
SFEI-ASC Program Manager[1]	Matthew Heberger	Matthew Heberger	4/9/2018
SFEI-ASC QA Officer	Don Yee	Don Yee	4/9/2018
SFEI-ASC Data Manager	Amy Franz	Amy Franz	4/9/18
SWAMP QA Officer	Melissa Morris	conditional approval, signature on file, see attachment	4/25/2018
SWRCB QA Officer	Renee Spears	Renee Spears	05-14-2018
MPSL Project Manager	Wes Heim	W. H.	May 1, 2018
MPSL QA Officer	Autumn Bonnema	Autumn Bonnema	1 May 2018
USGS Project Chief	Brian Bergamaschi	B. A.	May 1, 2018
USGS Program Chief	Joe Domagalski	J. L. Domagalski	May 14, 2018
Delta RMP SC co-Chair	Adam Laputz		May 11, 2018
Delta RMP SC co-Chair	Debbie Webster	Debbie Webster	11 May 18

[1]The SFEI-ASC Program Manager serves as the Contract Manager.

April 25, 2018

To: Matthew Heberger
San Francisco Estuary Institute - Aquatic Science Center
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510-746-7391

Re: Conditional Approval of Delta Regional Monitoring Program - Quality Assurance Program Plan Version 3.5, March 14, 2018

Thank you for the submission of the revised Delta Regional Monitoring Program - Quality Assurance Program Plan (QAPP) Version 3.5, dated March 14, 2018. In my opinion, the submitted document meets the requirements of a quality assurance project plan, with the exception of the missing detailed information on data review, validation, and corrective action procedures that was noted via email on January 10, 2018. These details are essential for evaluating data usability and comparability, both inside and outside of the project.

I hereby provide my approval of this version of the Delta RMP QAPP under the condition that a Standard Operating Procedures (SOP) document shall be prepared by project staff covering the missing level of detail. At a minimum, the SOP shall:

- Include the specific workflow, procedures, and business rules employed by project staff to review, verify, and validate Delta RMP data once it has been submitted by the lab or downloaded from the sensor.
- Include the specific conditions where data flags are used, the flag/code that is applied and its meaning/definition, and any comments that must be applied by staff or included by the lab.
- Include the specific conditions and procedures for triggering, implementing, documenting, and follow up on Corrective and Preventive Actions.
- Address all data types collected and utilized under the current project scope that require unique business rules to review, verify, and validate.

The final draft of the new SOP shall be submitted to the State Water Board and SWAMP QA Officers for review and approval on or before July 1st 2018. The SOP, when finalized and approved, shall become an attachment to the current and future QAPPs. The SOP shall be reviewed yearly, and revised as needed on the same schedule as the QAPP.

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2 Table of Contents

1 Title and Approval 2
2 Table of Contents 4
List of Tables 5
List of Figures 5
Acronyms and Abbreviations 6
3 Distribution List 10
4 Project Task/Organization 12
5 Problem Definition/Background 17
6 Program Tasks Description 22
7 Quality Objectives and Criteria 33
8 Specialized Training or Certifications 42
9 Documentation and Records 43
10 Sampling Process Design 44
11 Sampling Methods 47
12 Sample Handling and Custody 52
13 Analytical Methods and Field Measurements 55
14 Quality Control 58
15 Instrument/Equipment Testing, Inspection, and Maintenance 67
16 Instrument/Equipment Calibration and Frequency 68
17 Inspection/Acceptance for Supplies and Consumables 69
18 Non-direct Measurements 70
19 Data Management 70
20 Assessment and Response Actions 73
21 Reports to Management 74
22 Data Review, Verification, and Validation 74
23 Verification and Validation Methods 75
24 Reconciliation with User Requirements 81
25 References 82
26 Appendices 84

List of Tables

Table 3.1. Distribution list. 10
Table 4.1. Delta RMP Steering Committee. 13
Table 4.2. Delta RMP Technical Advisory Committee. 15
Table 4.3. Analytical laboratories. 17
Table 5.1. Beneficial uses associated with Delta RMP monitoring elements. 21
Table 5.2. Water quality objectives for mercury, biostimulatory substances, and dissolved oxygen (Central Valley Regional Water Quality Control Board 2011). 22
Table 6.1. Delta RMP target parameters and reporting units. 23
Table 6.2. Delta RMP reporting cycle. 32
Table 7.1. Summary of reporting limits (RL) and method detection limits (MDL) for Delta RMP constituents. 38
Table 10.1. Sampling sites and schedule. 46
Table 11.1. 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. 51
Table 11.2. Corrective actions procedures for field QC samples. 52
Table 12.1. Storage and hold time requirements for each parameter group. 52
Table 13.1. Summary of analytical methods and instruments. 57
Table 14.1. Field measurement quality objectives. 59
Table 14.2. Laboratory measurement quality objectives 62
Table 14.3. Corrective actions procedures for analytical laboratories. 66
Table 23.1. CEDEN controlled vocabulary for result qualifiers. 76
Table 23.2. Common CEDEN QA codes. 77
Table 23.3. Compliance Codes. 79
Table 23.4. Batch verification codes. 80

List of Figures

Figure 4.1. Delta Regional Monitoring Program organization chart. 12
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. 26
Figure 6.2. FY 2017-18 Mercury Monitoring Sites. 28
Figure 6.3. Proposed 3-day cruise track for FY17-18 high-resolution nutrient monitoring. 29

Acronyms and Abbreviations

Ap	particulate absorbance
ASC	Aquatic Science Center
BrCl	bromine chloride
CA	California
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
DQI	data quality indicator
DQO	data quality objectives
dw	dry weight
DWR	Department of Water Resources
EDD	Electronic Data Deliverable
EMP	Environmental Monitoring Program
EST	Estuarine Habitat Beneficial Use
fDOM	fluorescent dissolved organic matter
FNU	Formazin Nephelometric Units
FS	Forecasting scenarios
FY	fiscal year
g	gram
GLP	good laboratory practices
GPS	global positioning system
h	hours
HCl	hydrochloric acid
Hg	mercury
Hz	Hertz
H2SO4	sulphuric acid

ID	identification
KCl	potassium chloride
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
mm	millimeter
MPSL	Marine Pollution Studies Laboratory
MQO	measurement quality objective
MS	matrix spike
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)
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
NRCC	National Registry of Certified Chemists
NWIS	National Water Information System
NWQL	USGS National Water Quality Laboratory
OEHHA	California Office of Environmental Health Hazard Assessment
OFR	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
PC	Project Coordinator

PCA	principal component analysis
pH	potential of hydrogen
PI	Principal Investigator
POC	particulate organic carbon
POD	Pelagic Organism Decline
POTW	public owned treatment works
PPE	personal protection equipment
ppm/yr	parts per million per year
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/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
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
TM	Technical method(s)
TMDL	Total Maximum Daily Load
TOC	total organic carbon

TSS	total suspended solids
TWRI	Techniques of Water-Resources Investigations
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
WILD	Wildlife Habitat Beneficial Use
WQ	water quality
WT	water tracing
ww	wet weight
µg	microgram
µm	micrometer
µS/cm	micro-Siemens per centimeter
µM	micro-Molar
°C	degrees Celsius

3 Distribution List

Table 3.1. Distribution list.

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4 Project Task/Organization

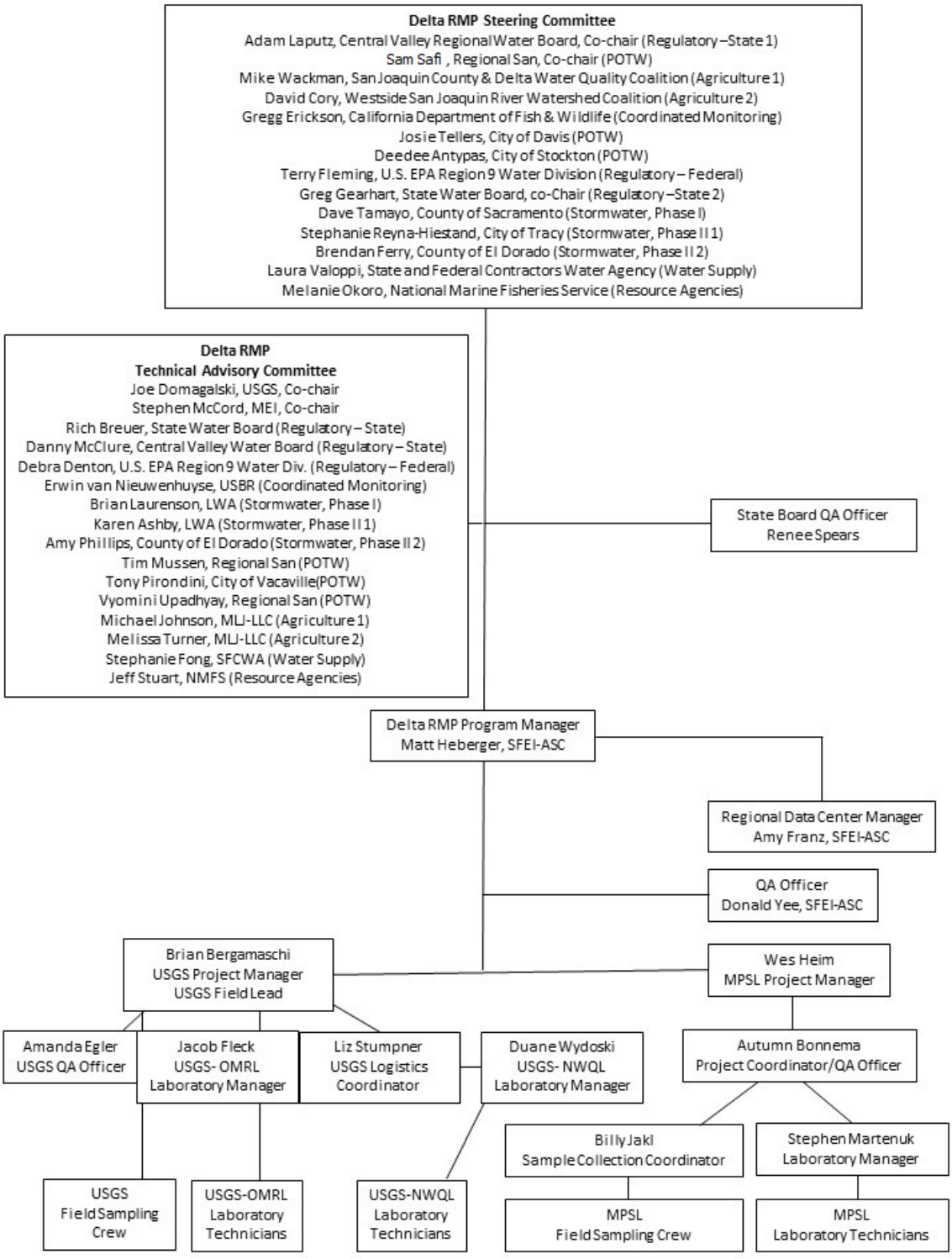

Figure 4.1. Delta Regional Monitoring Program organization chart.

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 2017/2018 (FY17/18) funding for the Delta RMP is provided by the wastewater treatment plants, stormwater municipalities, irrigated agriculture coalitions, and dredgers listed in Appendix A. FY17/18 funding also includes in-kind support from the Central Valley Water 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. Contact information for key staff is listed in Table 4.1.

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 the 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.

Name	Affiliation	Representing	Position
Mike Wackman	San Joaquin County & Delta Water Quality Coalition	Agriculture 1	Primary
Bruce Houdesheldt	Sacramento Valley Water Quality Coalition	Agriculture 1	Alternate
David Cory	Westside San Joaquin River Watershed Coalition	Agriculture 2	Primary
Parry Klassen	East San Joaquin Water Quality Coalition	Agriculture 2	Alternate
Gregg Erickson	Interagency Ecological Program/DFW	Coordinated Monitoring	Primary
Erwin Van Nieuwenhuyse	Interagency Ecological Program/Reclamation	Coordinated Monitoring	Alternate
Karen Gehrts	Interagency Ecological Program/DWR	Coordinated Monitoring	Alternate
Debbie Webster	CVCWA	POTW	Primary
Josie Tellers	City of Davis	POTW	Primary
Deedee Antypas	City of Stockton	POTW	Primary
Casey Wichert	City of Brentwood	POTW	Alternate

Nader Shareghi	Mountain House CSD	POTW	Alternate
Vyomini Upadhyay	Regional San	POTW	Alternate
Samsor Safis	Regional San	POTW	Alternate
Jenny Skrel	Ironhouse SD	POTW	Alternate
Tony Pirondini	City of Vacaville	POTW	Alternate
Dave Melilli	City of Rio Vista	POTW	Alternate
Tom Grovhoug	LWA	POTW	Alternate
Terry Fleming	U.S. EPA Region 9 Water Division	Regulatory-Federal	Primary
Valentina Cabrera-Stagno	U.S. EPA Region 9 Water Division	Regulatory-Federal	Alternate
Adam Laputz	Central Valley Regional Water Board	Regulatory-State 1	Primary
Pamela Creedon	Central Valley Regional Water Board	Regulatory-State 1	Alternate
Greg Gearheart	State Water Board	Regulatory-State 2	Primary
Vacant	State Water Board	Regulatory-State 2	Alternate
Dave Tamayo	County of Sacramento	Stormwater, Phase I	Primary
Dalia Fadl	City of Sacramento	Stormwater, Phase I	Alternate
Stephanie Reyna-Hiestand	City of Tracy	Stormwater, Phase II 1	Primary
Brandon Nakagawa	County of San Joaquin	Stormwater, Phase II 1	Alternate
Brendan Ferry	County of El Dorado	Stormwater, Phase II 2	Primary
Vacant		Stormwater, Phase II 2	Alternate
Laura Valoppi	SFCWA	Water Supply	Primary
Smith, Lynda	MWD	Water Supply	Alternate
Stephanie Fong	SFCWA	Water Supply	Alternate
Melanie Okoro	NMFS	Resource Agencies	Primary
Jeff Stuart	NMFS	Resource Agencies	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

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.

Table 4.2. Delta RMP Technical Advisory Committee.

Name	Representing	Affiliation
Greg Gearheart Alternate: Vacant	Regulatory – State	State Water Resources Control Board
Danny McClure Alternate: Janis Cooke	Regulatory – State	Central Valley Regional Water Board
Debra Denton Alternate: Valentina Cabrera-Stagno	Regulatory – Federal	U.S. EPA Region 9 Water Division
Erwin Van Nieuwenhuyse Alternate: Shaun Philippart	Coordinated Monitoring	US Bureau of Reclamation DWR-EMP
Brian Laurenson Alternate: Hope McCaslin Taylor	Stormwater, Phase I	Larry Walker Associates
Karen Ashby Alternate: Gerardo Dominguez	Stormwater, Phase II 1	Larry Walker Associates San Joaquin County
Amy Phillips Alternate: Vacant	Stormwater, Phase II 2	El Dorado County
Tim Mussen Tony Pirondini Vyomini Upadhyay Alternate: Lisa Thompson	POTW	Regional San City of Vacaville Regional San
Michael Johnson Alternate: Vacant	Agriculture 1	MLJ-LLC
Melissa Turner Alternate: Vacant	Agriculture 2	MLJ-LLC
Stephanie Fong Alternate: Vacant	Water Supply	SFCWA
Jeff Stuart Alternate: Vacant	Resource Agency	NOAA-NMFS
Joe Domagalski	USGS	TAC Co-chair
Stephen McCord	MEI	TAC Co-chair

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.

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.

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.

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.

Laboratories contracted by SFEI-ASC (Table 4.3) provide analytical services and will act as a technical resource to SFEI-ASC staff and management. Marine Pollution Studies Lab/Moss Landing Marine Labs will analyze tissue, sediment, and water for the mercury component.

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[2]
U.S. Geological Survey National Water Quality Laboratory	USGS-NWQL	Water	Nutrients, chl-*a*/phaeopigments[3]	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[4]

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

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

[3] Degradation products of algal chlorophyll pigments.

[4] 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.

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 12/03/2012 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) and priority assessment questions for each constituent (Appendix C). Pathogen monitoring began in FY14/15 to characterize levels of *Giardia* and *Cryptosporidium* throughout the Delta. Pathogen monitoring was designed as a 2-year special study and is now completed. Pesticides monitoring began in FY15/16 to provide information on spatial and temporal variability of pesticides and toxicity and is on hold after two years of monitoring, pending a redesign of this monitoring element. Mercury monitoring began in FY16/17 in order to address the highest priority information needs related to the implementation of the Methylmercury TMDL. Nutrient monitoring will begin 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 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 DRMP 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 linkage analysis discussed in the previous section, which 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.

5.1.2 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 (Central Valley Region Basin Plan or short, Bain Plan, Central Valley Regional Water Board 2011) and the Bay-Delta Water Quality Control Plan (Bay-Delta Plan, State Water Board 2006). The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Central Valley Region Basin Plan or Basin Plan) is the Central Valley Regional Water Board's regulatory reference for meeting the state and federal requirements for water quality control (40 CFR 131.20). It establishes numeric and narrative objectives for beneficial uses in the Sacramento River and San Joaquin River Basins, including the Sacramento-San Joaquin River Delta (Chapter III: Water Quality Objectives). The State Water Board adopted the Bay-Delta Plan to establish water quality objectives for the Bay-Delta Estuary related to flow and water project operations.

Table 5.1 provides an overview of beneficial uses that are relevant to the prioritized assessment questions (Appendix B) of each of the individual monitoring elements. Table 5.2 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 5.1. Beneficial uses associated with Delta RMP monitoring elements.

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

Table 5.2. 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[5]</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 /
Within the legal boundaries of the Delta 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[6]</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 Program Tasks Description

6.1 Water Quality Monitoring Overview

To address the management questions identified in Section 5.1, the Delta RMP will conduct water quality monitoring of mercury in water, sediment, and tissue, and nutrients in water. 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

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

[6] 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.

variability of nutrients and related water quality constituents in the Delta at the landscape scale. Table 6.1 provides a complete list of target parameters for the current implementation of the Delta RMP.

6.2 Constituents to be Monitored and Reported

Table 6.1. Delta RMP target parameters and reporting units.

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
Mercury – Fish Sampling					
Total Length	Fish Attributes	Tissue	Individual	n/a	mm
Fork Length	Fish Attributes	Tissue	Individual	n/a	mm
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	%
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
Oxygen, Dissolved	Field Measurements	Water	Grab	0.23	mg/L
Oxygen, Dissolved	Field Measurements	Water	Grab	n/a	% saturation
pH	Field Measurements	Water	Grab	n/a	pH
Specific Conductivity	Field Measurements	Water	Grab	10	µS/cm
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

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
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
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

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
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), including water bodies that directly drain into the Delta, 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.

Monitoring sites for mercury and the cruise tracks for nutrient monitoring are described in this section. Additional information for pesticide monitoring sites will be added later.

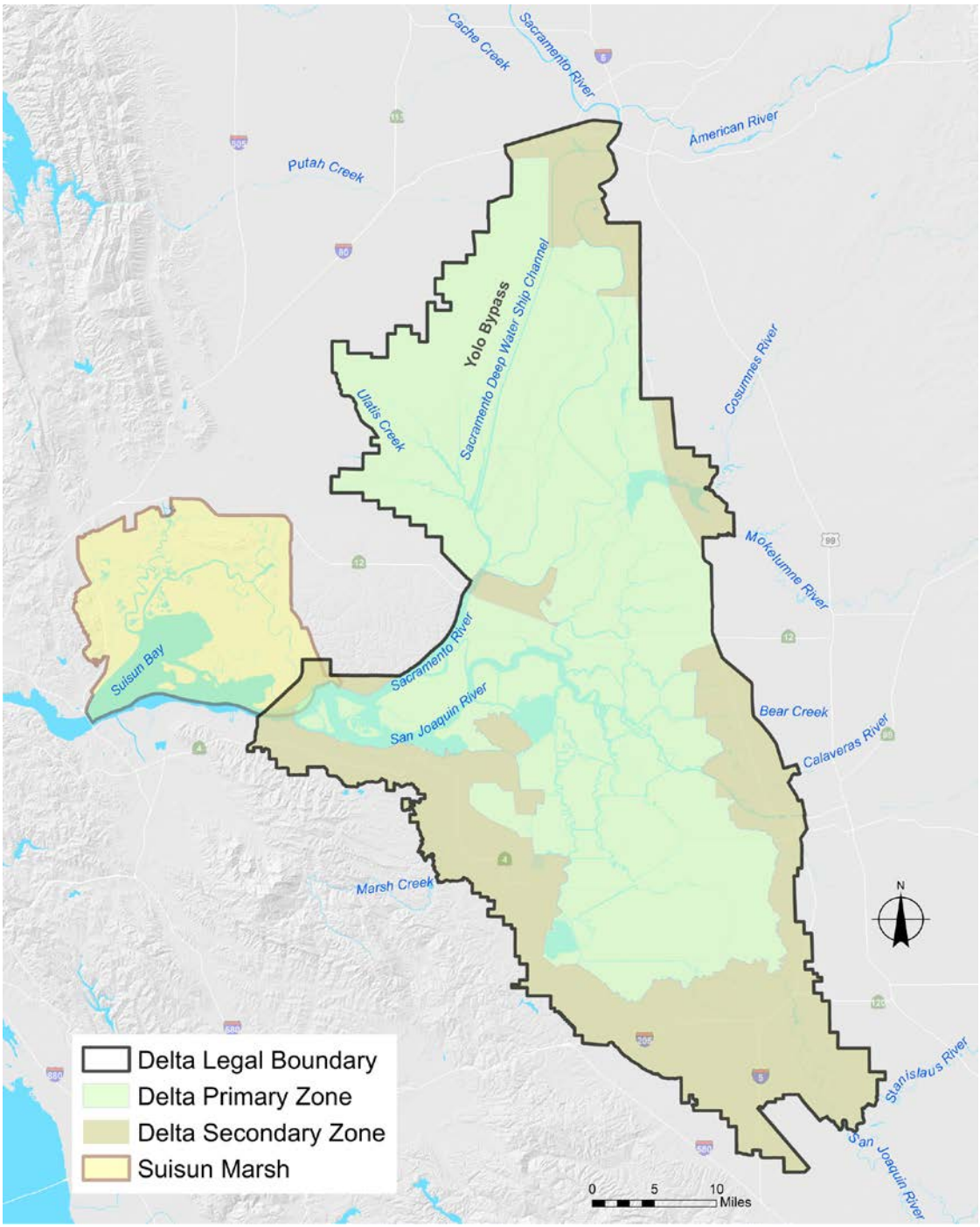

Figure 6.1. The geographic scope of the Delta RMP encompasses the legal Delta (as defined by section 12220 of the Water Code), including water bodies that directly drain into the Delta, Yolo Bypass, and Suisun Bay.

6.3.1 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 8 times per year and sediment samples will be collected 4 times per year (Section 10.1).

Figure 6.2 shows the mercury sampling sites. 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.

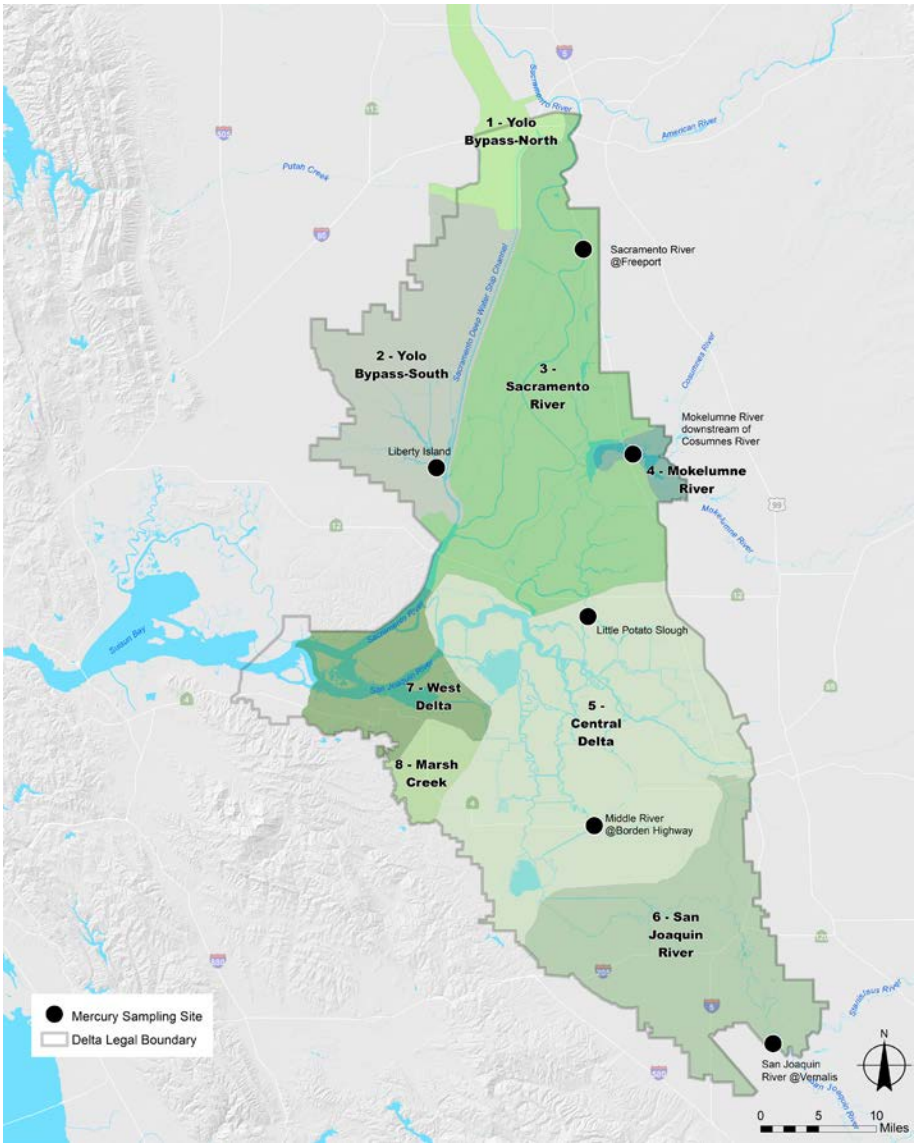

Figure 6.2. FY 2017-18 Mercury Monitoring Sites.

6.3.2 Nutrients

Three cruise tracks are proposed (Figure 6.3). 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 regions in the central Delta not served by long term monitoring.

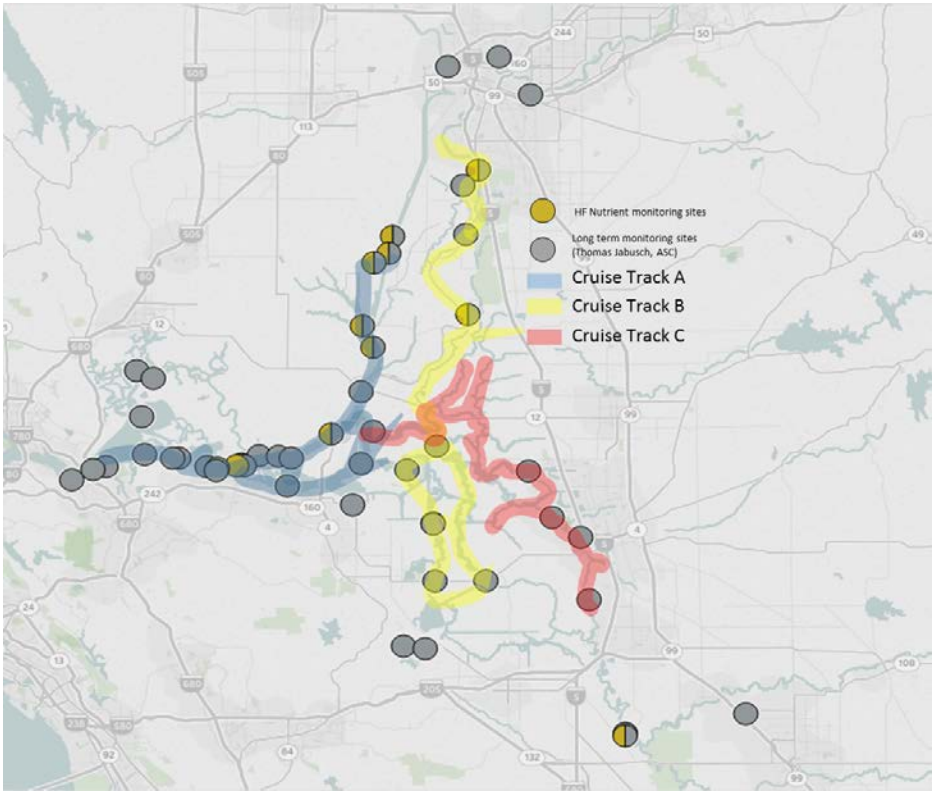

Figure 6.3. Proposed 3-day cruise track for FY17-18 high-resolution nutrient monitoring.

6.4 Constraints

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.

6.5 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 5.2.

6.5.1 Mercury

The specific monitoring questions for mercury are listed in Section 5.1.1. Mercury concentrations will be evaluated for trends in time series and compared to the fish tissue TMDL target listed in Table 5.2. Water concentrations for total methylmercury will be compared to the TMDL goal listed in Table 5.2. 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.

6.5.2 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 Products and Reporting

Table 6.2 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 Results Report) 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 6.2. 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: October 2018

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

6.6.1 QA Summary Report

The QA officer or designee writes 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
    - QB 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 to previous years
- Sums Summary

7 Quality Objectives and Criteria

7.1 Data Quality Objectives

7.1.1 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 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/yr, 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[7][8]. Monitoring of fish mercury and aqueous methylmercury is needed to: better quantify the fish-water linkage that is the foundation of the 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).

7.1.2 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] 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.

[8] 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.

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.

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 more than 90% of field measurements will be 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 data 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 and/or equipment blanks may be collected at the discretion of the QAO, when an established procedure is changed or when contamination problems are identified. 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.

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 11.1.

7.4 Laboratory Quality Control Measurements for Chemical Analyses

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 the QAPP 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 7.1. Summary of reporting limits (RL) and method detection limits (MDL) for Delta RMP constituents.

Constituent	Matrix	Reporting group	RL	MDL	Unit	Analyzing laboratory/ laboratories	Method used
Chlorophyll *a*	Water	Conventional	30	24	µg/L	MPSL (mercury monitoring), USGS (nutrient monitoring)	EPA 445.0 or EPA 446.0
Dissolved Organic Carbon	Water	Conventional	0.23	0.23	mg/L	MPSL	TM O-1122-92, METH011.00
Total Organic Carbon	Sediment	Conventional	NA	NA	%	MPSL	EPA 440
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
fDOM	Water	Field Parameters	0.07 - 300	0.07 - 300	QSE	USGS	
Nitrate	Water	Field Parameters	0.07 - 28	0.07 - 28	mg N/L	USGS	
Phycocyanin	Water	Field Parameters	0 - 100	0 - 100	µg/L	USGS	
Oxygen, Dissolved	Water	Field Parameters	0.5	0.5	mg/L	MPSL (mercury monitoring), USGS (nutrient monitoring)	
pH	Water	Field Parameters	4-8	4-8	NA	MPSL (mercury monitoring), USGS (nutrient monitoring)	
Specific Conductivity	Water	Field Parameters	10	10	µS/cm	MPSL (mercury monitoring), USGS (nutrient monitoring)	
Temperature	Water	Field Parameters	NA	NA	NA	MPSL (mercury monitoring), USGS (nutrient monitoring)	

Constituent	Matrix	Reporting group	RL	MDL	Unit	Analyzing laboratory/ laboratories	Method used
Turbidity	Water	Field Parameters	1	1	FNU	USGS	
Copper, dissolved	Water	Trace Metals	0.8	0.8	µg/L	USGS	TM-5-B1
Ammonium	Water	Nutrients	0.01	0.01	mg N/L	USGS	I-2525-89, I-2522-90
Nitrate	Water	Nutrients	0.02	0.02	mg N/L	USGS	I-2547-11
Orthophosphate	Water	Nutrients	0.008	0.008	mg P/L	USGS	I-2601-90, I-2606-89
Mercury, total	Tissue	Trace Metals	0.012	0.004	µg/g ww	MPSL	EPA 7473
Mercury, total (unfiltered)	Water	Trace Metals	0.200	0.070	ng/L	MPSL	EPA 1631E
Mercury, dissolved (filtered)	Water	Trace Metals	0.200	0.070	ng/L	MPSL	EPA 1631E
Mercury, total	Sediment	Trace Metals	0.012	0.004	mg/kg dw	MPSL	EPA 7473
Mercury, Methyl	Sediment	Trace Metals	0.013	0.004	µg/kg dw	MPSL	MPSL-110
Mercury, Methyl, total (unfiltered)	Water	Trace Metals	0.025	0.009	ng/L	MPSL	EPA 1630
Mercury, Methyl, dissolved (filtered)	Water	Trace Metals	0.025	0.009	ng/L	MPSL	EPA 1630

7.4.2 Laboratory QC Samples

Data from the laboratory 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 analytical batch (for analytical batches consisting of up to 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. Raw results for method blanks shall be reported.

Matrix spikes (MS) shall be run at a minimum frequency of one per batch or 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 3x 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 10-100x 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

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.

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[9]. 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:

$$\text{RPD} = \frac{\text{Difference (between replicate samples)}}{\text{Average (replicate samples)}} \times 100\%$$

7.4.4 Accuracy

The accuracy of lab measurements will be evaluated based on measurement quality objectives (Table 14.2) for LCS, MS/MSD, internal standards, surrogate recoveries, initial calibration, and calibration checks.

The percent recovery for MS is calculated using the equation

$$\%\ \text{recovery} = \frac{(\text{observed} - \text{background})}{\text{spike addition}}\ \text{x}\ 100$$

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

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

7.4.5 Contamination

For laboratory analyses, at least one laboratory method blank will be run in every sample batch, which should consist of 20 or fewer field samples prepared for analysis at one time. 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 > RL for any analytes of

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

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 Specialized Training or Certifications

The laboratory providing analytical support to the Delta RMP 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/Project Manager will need to 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). Delta RMP monitoring occurs in, upstream, and downstream of the Delta (Figures 6.2 and 6.3). The monitoring sites for mercury sampling represent different subareas of the Delta (Figure 6.2). Cruise tracks for nutrient monitoring represent nutrient gradients and under-monitored areas in the Delta (Figure 6.3).

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.

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 the Delta RMP Monitoring Design Summary.

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	Site Code	Target Latitude	Target Longitude	Sampling frequency	Schedule
Mercury					
Cache Slough at Liberty Island Mouth	510ADVLIM	38.24213	-121.68539	Fish: Annually Water: 8 times/year Sediment: 4 times/year	August 2017: Fish September 2017: Water, Sediment October 2017: Water March 2018: Water, Sediment April 2018: Water May 2018: Water, Sediment June 2018: Water July 2018: Water, Sediment August 2018: Water
Little Potato Slough	544LILPSL	38.09627	-121.49602		
Middle R @ Borden Hwy (Hwy 4)	544MDRBH4	37.89083	-121.48833		
Lower Mokelumne R 6	544ADVLM6	38.25542	-121.44006		
Sacramento R @ Freeport	510ST1317	38.4556	-121.50189		
San Joaquin R @ Vernalis/Airport Way	541SJC501	37.67556	-121.26417		
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

11 Sampling 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 (Table 11.1; 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, p59.

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 11.1). 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.

Table 11.1. 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[10]***	**Number of bottles/event**	**Sample Volume/Site**
Mercury	Trace metals Conventional[11]	Clear glass	7	4L
Nutrients	Nutrients Conventional	Amber glass	50	125 mL
Nutrients	Chl-*a*, chl-*a* > 5 µm	Amber glass	90	Requirement varies; typically 200-500 mL for both
Sediment				
Program Element	**Parameter Group**	**Container Type[12]***	**Number of containers/event**	**Target Sample Size/Site**
Mercury	Conventional[13]	Polypropylene jar or WhirlPac bag	13	60 mL
Mercury	Trace metals	Glass jar	13	60 mL
Fish				
Program Element	**Parameter Group**	**Primary Target[14]**	**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)

[10] 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.

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

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

[13] TOC, grain size.

[14] 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, 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

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), SFEI-ASC Project Manager, and the QA Officer.

Table 11.2. 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

Table 12.1 provides information about storage and hold time requirements for each parameter group.

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	28 day, if acidified	4 ± 2°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)
		H_2SO_4 per L within 48 hours of collection		
Chlorophyll *a* (Water)	0 - 6°C in dark	Filtration within 24 hours of collection	28 days	- 20°C in dark
DOC (Water)	0 - 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 - 6°C in dark	Cool to < 6°C within 24 hrs of collection	1 year	≤ - 20°C
Mercury, total (Water)	0 - 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 - 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 - 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 - 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 - 6°C in dark	Freeze at the end of day	1 year	≤ - 20°C
Total and Volatile Suspended Solids (Water)	4 ± 2°C in dark	Cool to 4 ± 2°C	7 days	4 ± 2°C

12.1 Trace Metals - Mercury

12.1.1 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 - 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.

12.1.2 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.

12.1.3 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.

12.2 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 (broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by NWQL.

12.3 Conventional Water Quality Parameters

12.3.1 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.

12.3.2 Dissolved Organic Carbon

DOC samples 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.

12.3.3 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 12.1.1 Sample Water.

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.

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

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

13.2.1 Analytical Methods

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 + 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)	
Chlorophyll *a* (2 methods)	*In Vitro* determination by fluorescence (EPA 445.0)	Turner TD700
	In Vitro determination by visible spectrophotometry (EPA 446.0)	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

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

13.2.2 Sample Archive and Disposal

Project samples will 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. Field measurement quality objectives.

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 standard laboratory methods.	Precision: Calibration to within 10% of nominal 2.5 µm S/N Accuracy/bias: Allowable drift ± 10%
Seabird model 45 Thermo-salinograph WET Labs beam transmissometer (676 nm)	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.	Precision: Allowable performance (accuracy) ± 10% for Specific Conductivity, ± 0.2 for pH, ± 5 turbidity units or ± 5% of the

Method	Parameters	QC check	Matrix	Frequency	Acceptable limits
YSI EXO 2				Temperature check with NIST certified thermistor - every 6 months	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:

1. 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.
2. 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.
3. Surrogate standards: analytes introduced to samples prior to sample extraction to monitor sample extraction method recoveries.
4. 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.
5. 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.
6. Lab reference materials/laboratory control samples: materials collected, bought, or created by a laboratory as internal reference samples, to track performance across batches.
7. Instrument replicates: replicate analyses of extracted material or standards that measure the instrumental precision.
8. 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. Laboratory measurement quality objectives

Method	Sample type	Matrix	Frequency	Acceptable limits
Conventional – Chlorophyll *a*				
EPA 445.0 or EPA 446.0	Calibration Verification	Water	Per 10 analytical runs	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
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	90-110% recovery

Method	Sample type	Matrix	Frequency	Acceptable limits
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	Per 10 analytical runs	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	Per 10 analytical runs	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
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

Method	Sample type	Matrix	Frequency	Acceptable limits
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				
EPA 1630	Laboratory Blank	Water	1 per 20 or batch	< RL
EPA 1630	LCS	Water	1 per 20 or batch	Expected value +/- 30%
EPA 1630	Matrix Spikes/Duplicates	Water	1 per 20 or batch	Expected value +/- 30% RPD < 25% for duplicates; n/a if concentration of either sample <RL
EPA 1630	Lab Duplicate	Water	1 per 20	RPD < 25%; n/a if concentration of either sample <RL

Method	Sample type	Matrix	Frequency	Acceptable limits
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

14.2.2 Corrective Actions Procedures

If chemical analytical laboratory results[15] fail to meet the MQOs, the corrective actions in Table 14.3 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.

Corrective actions procedures for analytical laboratories are summarized in Table 14.3.

[15] Including chlorophyll a.

Table 14.3. Corrective actions procedures for analytical laboratories.

Laboratory QC Sample Type	Corrective action
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 is 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.
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

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

See Section 14.1.

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) and from Downing et al. (2016) and Fichot et al. (2015).

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 data quality objectives stated in Section 7 and Section 14 and used only if they meet all of the specified criteria. 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. Acceptable sources include the USGS National Water Information System (NWIS, https://waterdata.usgs.gov/nwis) and the DWR Water Data Library (WDL, http://www.water.ca.gov/waterdatalibrary/).

19 Data Management

19.1 Entering and formatting of sampling and QA data results

19.1.1 Laboratory reporting of results

Chemical-analytical data will be reported 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 methods: 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 % recovery relative to certified or expected value.
- Matrix (or blank) spike results: include expected value (native + spike) for each analyte, actual recovered concentrations, calculated % 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 URL). 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 Section 19.1.1, Laboratory reporting of results. 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 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 and 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 is in the developing stages (USGS TM 1-D5, 37, and USGS TM9). Field data will be made available to interested parties the week following collection and report writing will occur in summer and fall of 2018.

19.2 Laboratory data report package information

Analytical results, including associated quality control samples (Section 14.2.2), 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 and QA codes are provided in Tables 23.1 and 23.2, respectively. A completed list of codes is available on CEDEN's Controlled Vocabulary web page. Details on the measurements and procedures that are expected to be used to demonstrate the quality of reported data can be found in Section 7, Data Quality Objectives, Criteria, and Control Procedures for Measurement Data.

19.3 Data storage/database

Data are managed by SFEI-ASC Data Services as established in Section 19. 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 (CD3) tool, usually within one year of sample collection. Data will also be made available through CEDEN's Advanced Query tool.

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 an Annual Monitoring Report, 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 Report will present the results of the previous July-June fiscal year of sampling. The main purpose of this report 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

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). 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 or p-scores >2, e.g., for acceptance criteria of ±25%, >±50%)[16] may be censored and not reported.

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:

1. 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.
2. 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).
3. 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.

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

[16] z-score = |result – expected value|/acceptable deviation. p-score = |RPD or RSD|/MQO%.

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
FO	Estimated maximum possible concentration (EMPC)

QA Code	Description
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 Verificaton	VAC
Cursory Verificaton, Incomplete QC, Flagged by QAO	VAC,VQI
Cursory Verificaton/Validation	VLC
Cursory Verificaton/Validation, Incomplete QC, Flagged by QAO	VLC,VQI
Cursory Verificaton/Validation, Minor Deviations, Flagged by QAO	VLC,VMD
Cursory Verificaton/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) 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 future 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.

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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	National Marine Fisheries Service (NMFS)
Water Supply	State and Federal Contractors Water Agency (SFCWA)
Coordinated Monitoring Programs	Interagency Ecological Program
Wastewater Treatment Plants	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 Municipalities	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	Port of Stockton Port of West Sacramento

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 mercury and nutrients. Questions highlighted in yellow were identified by the Steering Committee as the 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. 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? 2. 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?
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. 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? 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?

Type	Core Management Questions	Mercury	Nutrients
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 will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?
Effective-ness 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]	[none]

26.4 Appendix D. Short Summaries of Delta RMP Monitoring Elements

26.4.1 Mercury

Sport Fish

Annual sampling at 6 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 6 sites that align with sport fish monitoring sites 8 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.

Sediment

Sampling 6 sites that align with sport fish monitoring sites 4 times per year. Indicator of primary interest is total methylmercury in sediment.

Important ancillary parameters include total Hg and MeHg, TOC, and grain size.

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.

Field
USGS – National Field Manual for the Collection of Water-Quality Data (USGS TM Book 9) – 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
Chemical Analysis
USGS – Colorimetric Determination of Nitrate plus Nitrite in Water by Enzymatic Reduction, Automated Discrete Analyzer Methods (USGS TM5—B8) – Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis (EPA 440.0) – 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 (USGS OFR 92-480) – Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory - Determination of Inorganic and Organic Constituents in Water and Fluvial Sediments (USGS TWRI 5-A1) – Procedures for Processing Samples for Analysis of Dissolved Organic Carbon and Organic Particulate Carbon MPSL – Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis (EPA 440.0) – In Vitro Determination of Chlorophyll a and Pheaophytin a in Marine and Freshwater Algae by Fluorescence (EPA 445.0) – Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry (EPA 7473)

- Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry (EPA 1631, Revision E)
- Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry (EPA 1630)
- MPSL-101 Sample Container Preparation for Organics and Trace Metals, Including Mercury and Methylmercury
- MPSL-104 Sample Receipt and Check-In
- MPSL-110 Methyl Mercury in Sediments by Acidic KBr Extraction into Methylene Chloride
- SM 2540D Solids

26.6 Appendix F. Example Field Sheets

Attach ASR and WatList

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

USGS science for a changing world

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) _____

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

* see last page for additional codes

*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 06/09/07

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		
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										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)