A. PROJECT MANAGEMENT

1. Title Page and Approvals

QUALITY ASSURANCE PROJECT PLAN FOR WATER QUALITY MONITORING FOR THE YOLO BYPASS WATERSHED PLANNING PROJECT, 2003-2004

Contract Manager	Stefan Lorenzato, CalFed Contract Manager, CA Dept. of Water Resources	_____ Date
QA Officer	William Ray, State Water Resources Control Board	_____ Date
City Project Manager	Gary Wegener, City of Woodland	_____ Date
Consultant Project Manager	Armand Ruby, Larry Walker Associates	_____ Date
Contractor QA Officer	Claus Suverkropp, Larry Walker Associates	_____ Date

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3. Distribution List

Table A-1. Primary Distribution List for Quality Assurance Project Plan

Name	Agency or Company
Stefan Lorenzato	CalFed Contract Manager, CA Dept. of Water Resources
William Ray	QA Officer, State Water Resources Control Board
Casey Walsh Cady	CalFed Liaison, CA Dept. of Food and Agriculture
Gary Wegener	City of Woodland
Armand Ruby	Larry Walker Associates
Claus Suverkropp	Larry Walker Associates
Chris Erichsen	Larry Walker Associates
Todd Albertson	Caltest Analytical Laboratories
Frank Colich	Frontier Geosciences Inc.
Richard Danielson	BioVir Laboratories Inc.
Jeff Miller	Aqua Science, Inc.
Robin Kulakow	Yolo Basin Foundation

4. Project Organization and Responsibility

The Yolo Bypass Water Quality Monitoring Program (Monitoring Program) is being performed by the City of Woodland (the City) as part of a Yolo Bypass Watershed Planning Project. Principal funding for the planning project is provided by a grant from the CalFed Bay-Delta Program. The grant funding is provided subject to the terms of Contract # 4600001691, between Department of Water Resources (DWR) as administrator of the grant program, and the City of Woodland as grantee. The project manager under the grant agreement is Gary Wegener, Director of Public Works, City of Woodland. The project manager for the CalFed Bay-Delta Program is John Lowrie, and the State's contract manager for the agreement is Stefan Lorenzato, Watershed Management Coordinator for DWR. The CalFed project liaison for this project is Casey Walsh Cady, of the California Department of Food and Agriculture.

A stakeholders advisory group informs and influences the decision-making process of this project. These stakeholders include representatives of local municipalities and special districts, state and federal agencies, agriculture, recreational organizations, landowners, environmental organizations, the University of California at Davis, and watershed conservancies. The first of a series of stakeholder meetings was held on July 25, 2003. Sampling sites and pollutants of concern were identified at the second stakeholder meeting, October 15, 2003.

The consultant hired by the City to provide technical and other services for the watershed planning project, including planning and conducting the monitoring program, is Larry Walker Associates (LWA) of Davis, CA. The consultant project manager is Armand Ruby of LWA. The project quality assurance manager is Claus Suverkropp of LWA. Mr. Suverkropp has served in a similar capacity for the Sacramento River Watershed Program (SRWP) and will provide guidance and oversight to assure that the Yolo Bypass Monitoring Program is consistent with the quality assurance/quality control procedures followed by the SRWP.

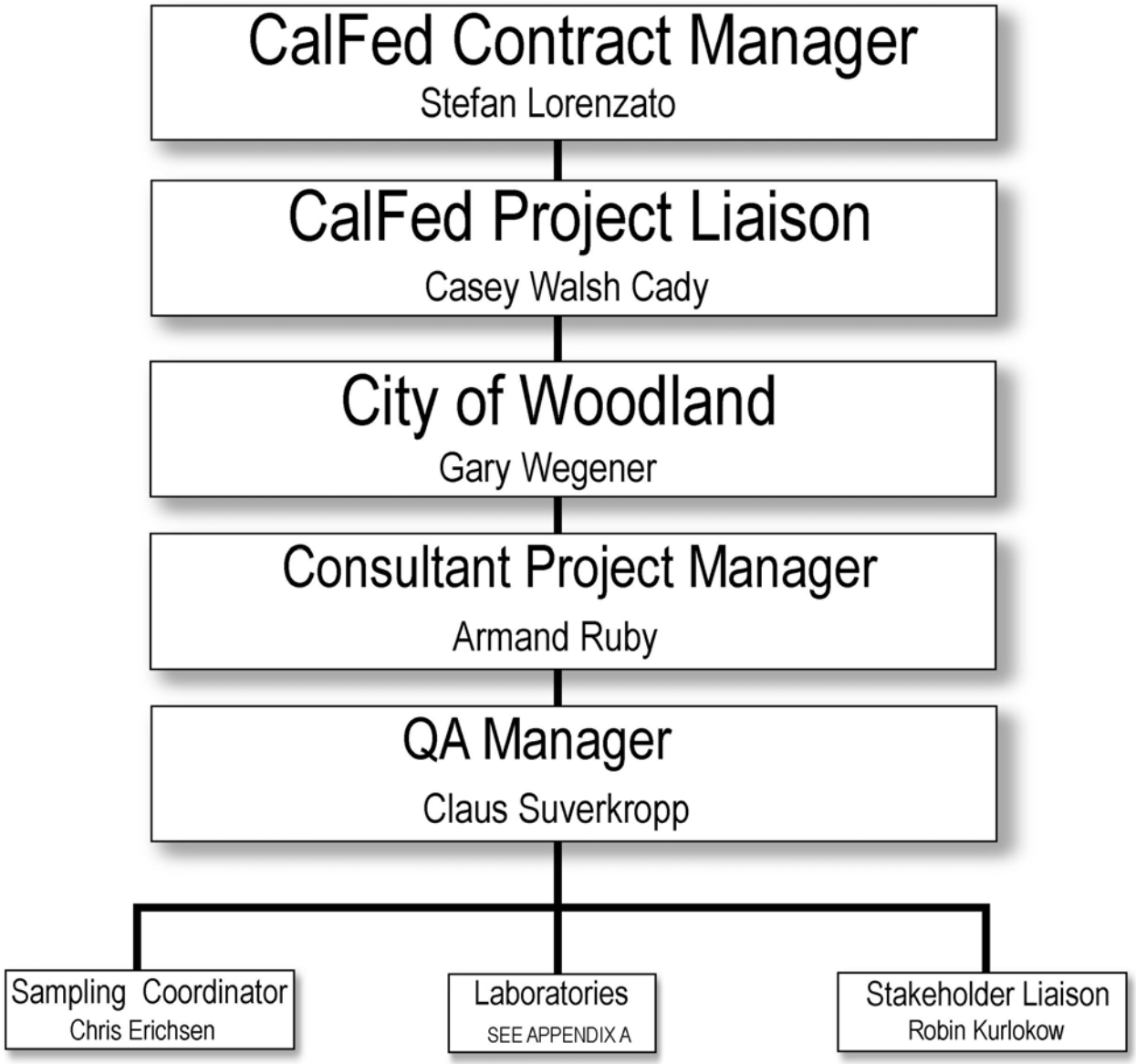
Sample analysis will be performed by the following subcontractors and municipalities:

- Caltest Analytical Laboratories
- Frontier Geosciences Inc.
- BioVir Laboratories, Inc.
- Aqua Science, Inc.
- City of Woodland Wastewater Treatment Plant
- City of Davis Wastewater Treatment Plant

Laboratory analytical responsibilities and primary contacts are listed in Appendix A.

The organizational structure of the Monitoring Program is illustrated in Figure A-1.

Figure A-1. Yolo Bypass Monitoring Program Management Structure



5. Problem Definition

The City of Woodland has received a CalFed grant (CalFed Grant # WSP01-FP-0073; DWR Agreement # 4600001691) to conduct Watershed Management Planning for water quality issues in the Yolo Bypass. The overall goal of the grant project is production of a comprehensive plan for improvement of water quality within the Yolo Bypass. The plan will account for the diverse interests in and uses of the Bypass, and will aim to make the best and most reasonable use of funds available for water quality improvement.

The scope of work covered by the grant includes a water quality monitoring program to characterize Bypass water quality. The monitoring program is scheduled to begin in November 2003 and continue for one year.

6. Project Description

Project Objectives and Approach

Three objectives complete the scope of this watershed planning effort. They are, (1) Define the pollutants of concern affecting the Yolo Bypass and downstream water bodies, (2) Collect data on the Bypass' water quality to identify pollutant sources, their magnitude, and seasonal variation, and (3) Define reasonable and implementable control measures for the pollutants of concern. A stakeholder group was formed to provide input and guidance on implementation of these objectives.

The monitoring program will augment other monitoring efforts that are ongoing in the watershed, including the USGS National Water Quality Assessment Program, Department of Water Resources, City of Woodland, City of Davis, and University of California at Davis. The monitoring program includes chemical, physical, biological and toxicological monitoring elements.

Measurements

The following environmental monitoring elements are included in the monitoring program:

- Mercury and methylmercury in water
- Heavy metals in water
- Organophosphorus, chlorinated, and carbamate pesticides in water
- Pathogen indicator organisms in water
- Organic carbon in water
- General constituents (solids, hardness, nitrate, color, boron) in water
- Toxicity in water

Specific individual parameters measured by the Yolo Bypass monitoring effort are listed in Table A-2. The purposes for monitoring these parameters are discussed below.

Mercury in water. Low levels of mercury and methylmercury in water are of potential concern to human health. Several programs are currently planned or under way in the Yolo Bypass watershed to monitor mercury levels at various locations, including the USGS National Water Quality Assessment. Monitoring of mercury and methylmercury has also been completed in

watersheds that drain into the Yolo Bypass, including the Sacramento River Watershed Program, the USGS National Water Quality Assessment, and the CalFed Bay-Delta Program. Proposed Yolo Bypass mercury monitoring will supplement existing data, and planned and ongoing monitoring efforts, with information for six locations. Data obtained will be used to quantify ambient levels of mercury and methylmercury in the Yolo Bypass watershed and to assess whether these levels are causing or contributing to potential human health risks or otherwise adversely affecting beneficial uses. Locations for mercury monitoring were selected to augment and coordinate with existing and planned monitoring efforts in the watershed.

Metals in water. Low levels of metals in water can affect the growth, reproduction and/or survival of sensitive aquatic species. Metals also pose a serious health risk to humans recreating in waters, as well as irrigated crops. Copper is a known serious issue in the Bypass. Many metals have a natural level of occurrence in surface waters, but urban runoff and mine tailings are sources of high metal concentrations such as boron, chromium, copper, iron, lead, and selenium. Yolo Bypass monitoring for metals at six sites will augment or continue fairly extensive monitoring conducted by the USGS NAWQA program, City of Woodland, City of Davis, and the University of California at Davis.

Pesticides in water. Low levels of pesticides in water can affect the growth, reproduction and/or survival of sensitive aquatic species. Pesticides of potential concern to aquatic life in the Yolo Bypass include Organophosphorus (OP), carbamate, and triazine pesticides. The USGS National Water Quality Assessment monitors pesticides in the Yolo Bypass. Yolo Bypass pesticide monitoring will supplement the existing data with information for six locations. Locations for pesticide monitoring were selected on the basis of documented use of these pesticides upstream from the locations monitored and on pesticide-caused toxicity detected in the Bypass.

Pathogen Indicators in water. Pathogens are disease-producing organisms (protozoa, bacteria, viruses) that adversely affect the quality of drinking water and may pose health risks for water contact recreation. Some pathogens are of particular concern, due to their ineffective removal by conventional municipal wastewater treatment technologies. The Tule Canal, the perennial drain on the eastern side of the Bypass, is seasonally used for fishing and small boat recreation, and is also a source of irrigation water for unprocessed crops. The Tule Canal becomes the Toe Drain as it flows southward past Interstate Route 80, and then drains into the Sacramento-San Joaquin Bay-Delta, a drinking water source for bay-delta communities including San Francisco. Because sampling and analysis for specific pathogen organisms is difficult and problematic, indicator organisms are often used as surrogates. Pathogen indicator monitoring will be employed to assess the presence of indicator organisms (total and fecal coliforms and *Escherichia coli*) at monitoring locations throughout the Bypass.

Organic carbon in water. The organic content of water (measured as organic carbon) is a parameter important to drinking water suppliers. High levels of organic compounds in source waters can lead to the production of disinfection by-products as a result of conventional water treatment. These by-products pose human health problems at relatively low concentrations. For these reasons, baseline data on typical organic carbon levels and seasonal variability of those levels in the Yolo Bypass are important to the assessment of drinking water uses. Yolo Bypass monitoring for organic carbon (dissolved and total) at six sites will augment or continue fairly

extensive monitoring conducted by the USGS NAWQA program, City of Woodland, City of Davis, and the University of California at Davis.

General constituents (suspended and dissolved solids, total and dissolved organic carbon, hardness, color, nitrate and boron) in water. These conventional water quality parameters are important to the evaluation of the attainment of a variety of uses, including drinking water supply, recreation, irrigation, aquatic habitat, and agricultural supply. Data on these parameters is available from a number of other programs, including USGS NAWQA, SRWP, City of Woodland, City of Davis, and the University of California at Davis. Yolo Bypass monitoring will augment these ongoing data collection efforts for these constituents at six sites.

Toxicity in water. Ambient samples of water can be tested in the laboratory for toxicity to provide an indication of the conditions that exist in the natural environment. Standard test species and test procedures are used to provide reliable and comparable results. Toxicity is considered to occur when test species are adversely affected by exposure to ambient water. Adverse effects may include impaired growth or reproduction, abnormalities, or mortality of test species. Effects may occur rapidly (acute toxicity) or may occur over a longer period (chronic toxicity). Toxicity testing in water will be performed at four locations in the watershed to assess chronic toxicity testing using both the fathead minnow (P*imephales promelas*) and the water flea (*Ceriodaphnia dubia*). Sites for aquatic toxicity monitoring were selected to provide an overall survey of the distribution of toxicity in the watershed, to coordinate with existing monitoring programs, and to characterize causes of observed toxicity.

Table A-2. Parameters Measured for the Yolo Bypass Monitoring Program

Analyte
Organophosphate Pesticides by EPA 614/8141
Chlorinated Pesticides by EPA 608/8081
Carbamates by EPA 632/8032
Mercury (total)
Methyl Mercury
Metals (B, Al, Cu, Fe, Cr, Pb, Se) - dissolved and total
Hardness
Nitrate
TOC
Color
DOC
TSS
TDS
Total & Fecal Coliform, plus E. coli
Chronic Toxicity

Assessment Tools

The QAPP and any amendments to QAPP elements will be reviewed and approved by project Quality Assurance Officers, and by the Quality Assurance Manager prior to the initiation of monitoring.

Project Schedule

The proposed schedule for Yolo Bypass monitoring is summarized in Table A-3.

Table A-3. Project Implementation Schedule for 2003-2004 Monitoring

Finalize and Execute Contracts for 2003-2004 Monitoring	11/1/03
Submit Revised QAPP to CalFed for Review	11/12/03
Receive Comments on Amended QAPP	12/8/03
Respond to CalFed Comments on Revised QAPP	12/22/03
Conditional Approval for QAPP for 2003-2004 Monitoring	11/21/03
Initiate 2003-2004 Monitoring	11/22/03
Final Approval for QAPP	12/31/03

Sampling Schedule

The sample collection frequency varies by site, flooding season, and parameter to be tested. The proposed monitoring includes six sites and six events (bimonthly) for most constituents, and 10 sites and 12 events for mercury, bacteria, and the field parameters. (Note that although there are 12 sites, under typical conditions the Fremont Weir and Sacramento Weir will not be spilling, so of the 12 sites only 10 will nominally be collectable.)

7. Quality Objectives and Criteria for Measurement Data

The objective of data collection for this program is to produce data that represent, as closely as possible, *in situ* conditions of the Yolo Bypass watershed. This objective will be achieved by using the methods specified in this QAPP to collect and analyze water samples. Assessing the program's ability to meet this objective will be accomplished by evaluating the resulting laboratory measurements in terms of detection limits, precision, accuracy, comparability, representativeness, and completeness, as presented in Section B of this document.

8. Documentation and Records

Data to be included in data reports

For each sample event, the field crew shall provide the Quality Assurance Manager with copies of relevant pages of the field logs and copies of the Chain of Custody forms for all samples submitted for analysis. At a minimum, the following sample-specific information will be provided for each sample collected:

- sample ID (unique for each sample and replicate)
- monitoring location
- sample depth
- sample type, e.g. grab or composite type (cross-sectional, flow-proportional, etc.)
- number of sub-samples in composite (if appropriate)
- QC sample type (if appropriate)
- date and time(s) of collection
- requested analyses (specific parameters or method references)

For each sample analyzed, the analyzing laboratory shall provide the Quality Assurance Manager with the following information:

- sample ID
- date of sample receipt
- dates of analysis
- analytical method(s)
- method detection limit (if appropriate)
- reporting limit (if appropriate)
- measured value of the analyte or parameter.

In addition, the analyzing laboratory shall provide results from all laboratory QC procedures (blanks, duplicates, spikes, reference materials, etc.) and the sample IDs associated with each analytical sample batch.

Reporting Format

In addition to the laboratory's standard reporting format, all results meeting data quality objectives, and results having satisfactory explanations for deviations from objectives, shall be reported in tabular format on electronic media.

B. DATA ACQUISITION

1. Sampling Design

The monitoring program includes monitoring at 10 locations in the Yolo Bypass. Four sites are located on the perennial channel, the Tule Canal (e.g., Toe Drain). Eight sites are located on major inputs to the Bypass, including two sites at flood weirs. These sites cover over 45 miles of the Yolo Bypass system and represent a drainage area of over 59,000 acres. The Yolo Bypass monitoring sites are listed in Table B-1 and illustrated in Figures B-1 and B-2.

Water quality monitoring samples will be collected as "event-based" grab samples. Table A-3 in the previous section provides a summary of sampling frequency and parameters monitored at each site.

Table B-1. Yolo Bypass Monitoring Sites

Site description	Site ID	Site Type
Sacramento River Overflow/Fremont Weir	1	Input – Sac R overflow
Knight's Landing Ridge Cut	2	Input channel
Cache Creek	3	Input creek
Willow Slough Bypass	4	Input channel
Yolo Bypass Wildlife Area – lift pump	5	Input – pumped
Putah Creek	6	Input creek
Z Drain – Dixon RCD	7	Input channel
Sacramento River Overflow/Sacramento Weir	8	Input – Sac R overflow
Tule Canal – Woodland R1	9	East side drain channel
Tule Canal – Woodland R2	10	East side drain channel
Tule Canal at north-east corner of I-80	11	East side drain channel
Toe Drain at north-east corner of Little Holland	12	East side drain channel

Figure B-1. Sampling Sites, Northern Yolo Bypass

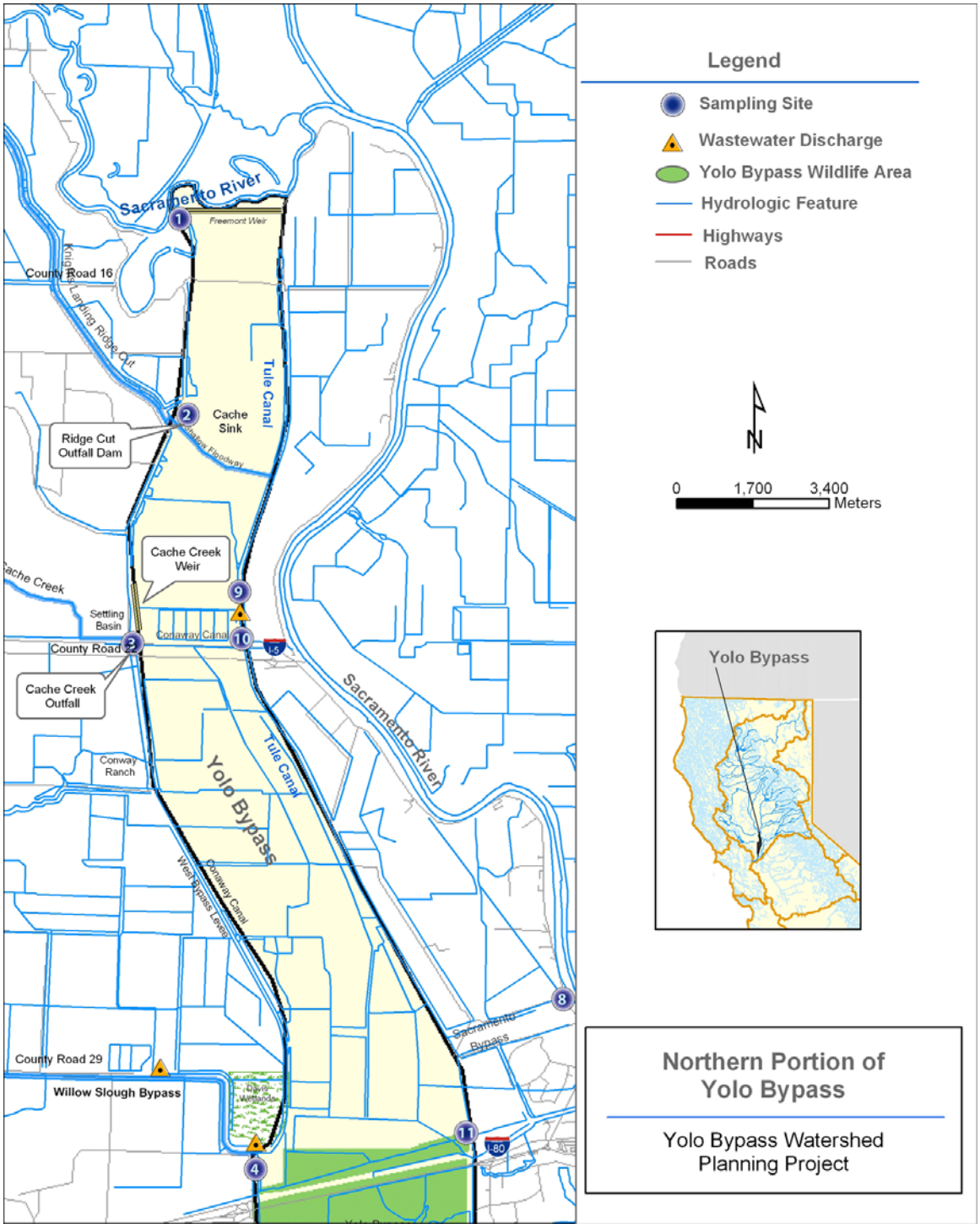
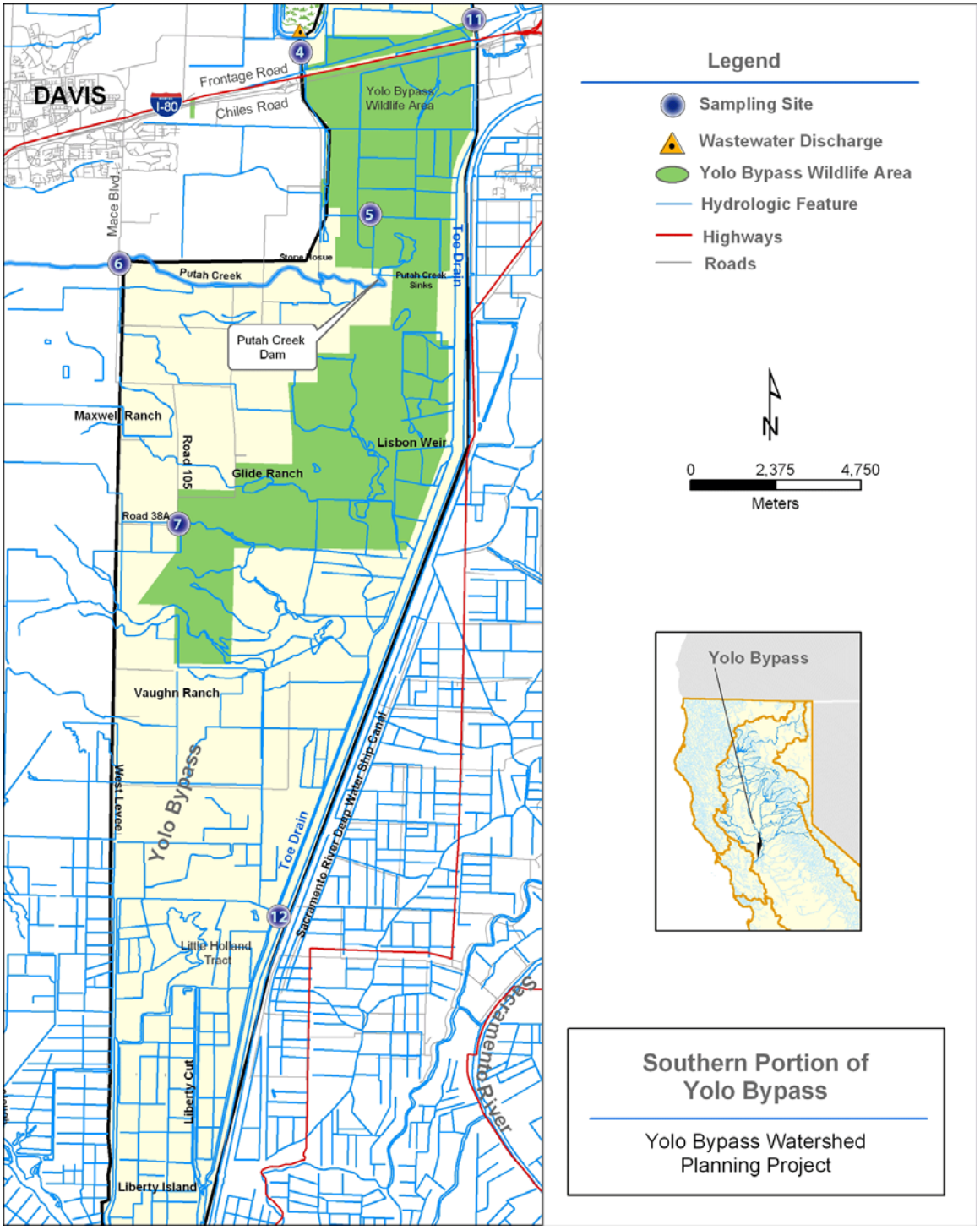


Figure B-2. Sampling Sites, Southern Yolo Bypass



2. Sampling Methods Requirements

Samples will be collected from surface waters only. Three different sample collection methods will be used for the monitoring elements in water: (1) basic water quality sampling, (2) pathogen indicator sampling, and (3) toxicity sampling. For each of these methods described or referenced, it is the combined responsibility of the contractor's QA manager and sampling coordinator to determine if the performance requirements of the specific sampling method have been met, and to collect an additional sample if required. Sampling personnel will carry copies of the QAPP and any relevant SOPs with them in the field for reference during sampling. Descriptions of specific sampling methods and requirements are provided below.

2.1 Basic Water Quality Characteristics

Basic water quality monitoring will include sampling for mercury and methylmercury, pesticides, metals (Al, B, Cu, Be, Cr, Pb, Se), hardness, total suspended solids, total dissolved solids, nitrate, total organic carbon, dissolved organic carbon, and color. Field-measured parameters (temperature, dissolved oxygen, specific conductivity, and pH) will also be measured at each site and event. Field parameters will be measured using a YSI Model 57 Oxygen Meter for dissolved oxygen, VWR Scientific Traceable Digital Thermometer (Cat. #61220416) for temperature, Orion Model 230A pH meter, and an Orion Model 130 conductivity meter, or comparable instrument(s).

All water quality samples will be collected using clean techniques that minimize sample contamination. Sampling methods will generally conform to EPA "clean" sampling methodology described in *Method 1669: Sampling Ambient Water for Trace Metals* (USEPA 1995a). Specific methods are also documented in Appendix B. Samples will generally be mid-depth grab samples and will be collected from shore using an extendable grab pole or using a peristaltic pump and acid-cleaned polyethylene or Teflon™ tubing. Grab samples will be collected directly into the required sample containers.

After collection, samples will be stored at 4˚C until arrival at the contract laboratory. Samples to be analyzed for mercury will be preserved using ultrapure hydrochloric or bromochloric acid at the contract laboratory, immediately on arrival. Samples to be analyzed for other constituents will be preserved in the field, as appropriate (Table B-2).

This sample collection method requires that the sample collection tubing, and the sample bottle and lid come into contact only with surfaces known to be clean, or with the water sample. Additionally, mercury samples must have no air bubbles or head space present in the bottle immediately following sample collection. If air is present in the sample container for mercury analyses, additional sample will be aliquotted into the same sample bottle. If the performance requirements for specific samples are not met, the sample will be re-collected. If contamination of the sample container is suspected, a fresh sample container will be used.

2.2 Pathogen Indicators

Pathogen monitoring will include sampling for pathogen indicator organisms (fecal and total coliform bacteria, and *E. coli*). Samplers must wear gloves when collecting any pathogen indicator samples.

Bacteria

Samples analyzed for bacteria will be collected as near-surface grab samples from mid-stream. Sampling for bacteria will be performed according to the sampling procedures detailed for Standard Methods 9221B and 9221E (APHA *et al*. 1995). In brief, the sampling procedures are summarized as follows:

- Sample containers should be cleaned and sterilized using procedures described in Standard Methods 9030 and 9040.
- Wherein waters suspected to contain a chlorine residual, sample bottles should contain a small amount of sodium thiosulfate ($Na_2S_2O_3$) sufficient to neutralize bactericidal activity. For water containing high concentrations of copper or zinc, sample bottles should contain sufficient EDTA solution to reduce metal toxicity. Note that these conditions are rare in surface waters.
- Sample bottles may be glass or plastic (e.g. polypropylene) with a capacity of at least 120 mL. Once sterilized, sample bottles are to be kept closed until they are to be filled.
- When removing caps from sample bottles, be careful to avoid contaminating inner surface of caps or bottles.
- Using aseptic techniques fill sample bottles leaving sufficient air space to facilitate mixing by shaking. Do not rinse bottles.
- Recap bottles tightly.

If at any time the sampling crew suspects that the sample or sampling container has been contaminated, the sample should be re-collected into a new sample container.

After collection, store samples at 4˚C until arrival at the contract laboratory. Bacteriological tests must be set up within 6 hours from collection. The 20th edition of Standard Methods (APHA et al. 1995) recommends analysis of samples as soon as possible, but specifies that potable water samples analyzed for compliance purposes may be held for up to 6 hours (below 10˚C) until time of analysis.

2.3 Aquatic Toxicity

Collection of water samples for analysis of ambient water column toxicity will be performed in accordance with guidance for sampling and sample handling documented in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms* (USEPA 1994a). In brief, the sampling requirements for toxicity testing are as follows:

- Water collected for toxicity tests will consist of grab samples.
- Samples will be collected directly into 4-L amber glass bottles, using the same equipment and procedures as for basic water quality samples (previously described in section 2.1).
- Samples will be filtered in the laboratory as required for specific toxicity tests.
- After collection, samples will be chilled and maintained at 4˚C until testing.
- Toxicity tests will be initiated within 48 hours of sampling.

In some cases where significant toxicity is observed during aquatic toxicity testing, samples may be analyzed for any of the chemical parameters included in this QAPP. The specific analyses to be performed will depend on the pattern of toxicity observed, including any decision to filter samples for chemical analysis. Every effort will be made to be consistent with the sample requirements documented herein for the specific analyte. Because requirements for sample and preservation holding times, filtration, and original sample containers may not be strictly met, the results of the analyses will be used primarily for determining or confirming causes of toxicity, and will be qualified for any other use. Laboratories selected to perform these analyses must meet the same QA performance criteria used to select other laboratories for this monitoring program.

A summary of the numbers of sampling sites and events for the parameters to be analyzed is provided in Table B-3. A schedule of the sampling frequency for analytes by site and event are provided in Table B-4. The list of sampling sites in Table A-3 supersedes all lists of sampling sites included in previous versions of QAPPs or monitoring plans, approved or unapproved, relating to the monitoring described herein.

Table B-2. Sampling Requirements

Parameter	Sample Container	Sample Volume[1]	Immediate Processing and Storage	Holding Time[2]
Mercury				
Total Mercury	Teflon™, or glass w/ PTFE-lined cap	250 mL	Store at 4°C; Preserve with HCl within 48 hours	28 days
Methylmercury[3]	Teflon™, or glass w/ PTFE-lined cap	250 mL	Store at 4°C; Preserve with HCl within 48 hours	6 months
Pesticides				
Organophosphates	Amber Glass	1 Liter	Store at 4°C; Extract within 7 days	7 days
Carbamates	Amber Glass	1 Liter	Store at 4°C; Extract within 7 days	7 days
Chlorinated	Amber Glass	1 Liter	Store at 4°C; Extract within 7 days	7 days
General Constituents				
Hardness	Polyethylene	250 mL	Preserve to =pH 2 with HNO3; Store at 4°C	6 months
Total Suspended Solids	Polyethylene	200 mL	Store at 4°C;	7 days
Total Dissolved Solids	Polyethylene	100 mL	Filtered; Store at 4°C	7 days
Total Organic Carbon	Amber Glass, PTFE-lined cap	40 mL	Preserve w/ H_2SO_4; Store at 4°C;	7 days
Dissolved Organic Carbon	Amber Glass, PTFE-lined cap	40 mL	Field-filtered[3]; Preserve w/ H_2SO_4; Store at 4°C;	7 days
Color	Polyethylene	100 mL	Store at 4°C;	48 hours
Nitrogen and Phosphorus Compounds				
Nitrate	Polyethylene	500 mL	Store at 4°C	48 hours
Pathogens				
Total & fecal coliforms, *E. coli*	Polyethylene	100 mL	Store at 4°C	6 hours[4]
Toxicity				
Aquatic bioassays and chemistry[6]	Amber Glass	10 L	Store at 4°C	36 hours[5]
Metals				
Trace metals (total & dissolved) (Al, B, Cu, Be, Cr, Pb, Se),	Polyethylene	500 mL	Filter for dissolved fraction prior to preservation Preserve to =pH 2 with HNO3; store at 4°C	6 months

1. Additional volumes may be required for QC analyses; NA = Not Applicable
2. Holding time after initial preservation or extraction.
3. Field-filtration and preservation are preferred, but DOC samples may be filtered and preserved in the laboratory within 48 hours, if field filtration is not practical.
4. Samples for bacteria analyses should be set up as soon as possible.
5. Results for tests initiated after 36 hours will be qualified, as appropriate.
6. For interpretation of toxicity results, samples may be split from aquatic toxicity samples in the laboratory and analyzed for specific chemical parameters. All other sampling requirements (sample containers, filtration, preservation, holding times) for these samples are as specified in this document for the specific analytical method. Results of these analyses are qualified for any other use (e.g. characterization of ambient conditions) because of potential holding time exceedances and variance from sampling requirements.

Table B-3. Summary of Sampling Sites, Frequency, and Parameters.

Analyte	Laboratory	Sites	Events
Organophosphate Pesticides by EPA 614/8141	CalTest	6	6
Chlorinated Pesticides by EPA 608/8081	CalTest	6	6
Carbamates by EPA 632/8032	CalTest	6	6
Mercury (total)	Frontier	10	12
Methyl Mercury	Frontier	6	6
Metals (Al, B, Be, Cu, Cr, Pb, Se)	CalTest	6	6
Nitrate	CalTest	6	6
Hardness	CalTest	6	6
Color	CalTest	6	6
TDS	CalTest	6	6
TOC	CalTest	6	6
DOC	CalTest	6	6
TSS	CalTest	6	6
Total & Fecal Coliform, and *E. coli*	BioVir	10	12
3-Species Chronic Toxicity	TBD	4	4
Field Measurements			
Electrical Conductivity		10	12
Turbidity		10	12
Dissolved Oxygen		10	12
pH		10	12
Temperature (F)		10	12

Table B-4. Sampling Schedule for Analytes by Site and Event

SITE		EVENTS											
		Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct
Class	#	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Inputs	**1**			1,2,4	1,2,4	1,2,4							
	2	1,2,3,4	1	1,2,3,4,5	1	1	1,2,3,4,5	1	1,2 ,3,4	1,	1,2,3,4,5	1,2.3,4,5	1
	3	1,2,3,4	1	1,2,3,4,5	1	1	1,2,3,4,5	1	1,2 ,3,4	1	1,2,3,4,5	1,2,3,4,5	1
	4	1,2,3,4	1	1,2,3,4,5	1	1	1,2,3,4,5	1	1,2 ,3,4	1	1,2,3,4,5	1,2,3,4,5	1
	5	1	1	1	1	1	1	1	1	1	1	1	1
	6	1,2,3,4	1	1,2,3,4	1	1	1,2,3,4	1	1,2 ,3,4	1	1,2,3,4	1,2,3,4	1
	7	1	1	1	1	1	1	1	1	1	1	1	1
	8			1,2,4	1,2,4	1,2,4							
East Channel	**9**	1	1	1	1	1	1	1	1	1	1	1	1
	10	1	1	1	1	1	1	1	1	1	1	1	1
	11	1,2,3,4	1	1,2,3,4,5	1	1	1,2,3,4,5	1	1,2 ,3,4	1	1,2,3,4,5	1,2,3,4,5	1
	12	1,2,3,4	1	1,2,3,4	1	1	1,2,3,4	1	1,2 ,3,4	1	1,2,3,4	1,2,3,4	1

1 = Total Mercury and Total and fecal coliforms, including E. Coli (10/12)

2 = Methylmercury and Trace Metals (6/6)

3 = Pesticide group: Chlorinated, organophosphorus, and carbamates (6/6)

4 = General constituents: Hardness, TOC, DOC, TSS, TDS, Color, and Nitrate (6/6)

5 = Aquatic bioassay and chemistry (4/4)

Grey *indicates site sampled only when weir is breached*

3. Sample Handling and Custody

All samples will be packed in wet ice or frozen ice packs during shipment, so that they will be kept at approximately 4˚C. Samples will be shipped in insulated containers. All caps and lids will be checked for tightness prior to shipping. All samples will be handled, prepared, transported and stored in a manner so as to minimize bulk loss, analyte loss, contamination or biological degradation. Sample containers will be clearly labeled with an indelible marker. Where appropriate, samples may be frozen to prevent biological degradation. Water samples will be kept in Teflon™, glass, or polyethylene bottles and kept cool at a temperature of 4˚C until analyzed. Maximum holding times for specific analyses are listed in Table B-2.

All samples remaining after successful completion of analyses will be disposed of properly. It is the responsibility of the personnel of each analytical laboratory to ensure that all applicable regulations are followed in the disposal of samples or related chemicals.

Chain-of-custody procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. A complete chain-of-custody form is to accompany the transfer of samples to the analyzing laboratory. A sample is considered under custody if:

- it is in actual possession;
- it is in view after in physical possession;
- it is placed in a secure area (accessible by or under the scrutiny of authorized personnel only after in possession)

With the exception of aquatic toxicity samples, samples will be kept for a minimum of 28 days after collection. The QA officer for each laboratory will evaluate the data before the end of the 28 day period. After this period, samples may be disposed of properly when all analyses have been completed, and data quality objectives have been met. Aquatic toxicity samples may be disposed of after initial testing is complete and no further analyses are warranted.

3.1 Sample Holding Times

Data quality objectives for sample holding times conform to recommendations documented in the analytical methods for individual parameters. The contract laboratory will analyze all samples before the maximum allowable holding time for any sample is exceeded. Holding times for specific parameters are presented in Table B-2.

3.2 Field Log

Field crews shall be required to keep a field log for each sampling event. The following items should be recorded in the field log for each sampling event:

- site name and/or number;
- time of sample collection;
- sample ID numbers, including etched bottle ID numbers for Teflon™ mercury sample containers and unique IDs for any replicate or blank samples;
- results of any field measurements (temperature, D.O., pH, conductivity, turbidity) and the time that measurements were made;

- qualitative descriptions of relevant water conditions (e.g. color, flow level, clarity) or weather (e.g. wind, rain) at the time of sample collection;
- description of any unusual occurrences associated with the sampling event, particularly those that may affect sample or data quality.

Appropriate pages from the sampling log will be photo-copied and transmitted to the Quality Assurance Manager at the conclusion of each sampling run.

The field crews shall have custody of samples during field sampling. Chain of custody forms will accompany all samples during shipment to contract laboratories. All water quality samples will be transported to the analytical laboratory by the field crew or by overnight courier.

3.3 Laboratory Custody Log

Laboratories shall maintain custody logs sufficient to track each sample submitted and to analyze or preserve each sample within specified holding times.

4. Analytical Methods Requirements

4.1 Basic Water Chemistry Analyses

Water quality samples may be analyzed for filtered and unfiltered fractions of mercury and methylmercury, trace elements, pesticides, and conventional water quality constituents. Analytical methods are summarized in Tables B-5 through B-8.

Field Measurements

Prior to analysis of any environmental samples, the field equipment must have demonstrated the following instrument measurement resolutions:

Parameter	Resolution
Dissolved Oxygen	0.1 standard unit
Flow (cfs)	0.1 cfs
pH	0.1 standard unit
Speicifc Conductivity	10 microSiemens/cm
Temperature	0.5 ˚C

Mercury and Trace Metals

Prior to analysis of any environmental samples for mercury, methylmercury, or other trace metals, the laboratory must have demonstrated the ability to meet the minimum performance requirements for each analytical method. Initial demonstration of laboratory capability includes the following:

- the ability to produce a detection limit equal to or less than the method detection limit (MDL) listed in Table B-5;
- the ability to generate acceptable precision and recovery, as defined by *s* and *X* in Table B-5;
- the ability to generate average recoveries within 15% of the stated concentration in a Standard Reference Material (SRM).

Procedures for analytical performance requirements, extraction procedures, and waste disposal and pollution prevention requirements are detailed in the laboratory's Standard Operating Protocols or EPA Method documents for each analytical method. EPA's recommended minimum performance requirements are summarized for each trace element in Table B-5.

Pesticides

Prior to analysis of any environmental samples for pesticides, the laboratory must have demonstrated the ability to meet the minimum performance requirements for each analytical method. Initial demonstration of laboratory capability includes the following:

- the ability to produce a reporting limit equal to or less than the reporting limit (RL) listed in Table B-6;
- the ability to generate acceptable precision and recovery, as defined by the specified method;

Procedures for demonstrating analytical performance requirements, extraction procedures, and waste disposal and pollution prevention requirements are detailed in the EPA Method documents for each analytical method. EPA's recommended minimum performance requirements are summarized in the method documents.

Conventional Constituents

Analyzing laboratories must demonstrate the ability to produce reporting limits approximately equal to or below the estimated reporting limits listed in Table B-7. Precision and replicate measurements in ambient waters should be less than 20% Relative Percent Difference for all constituents. Average recovery of appropriate reference materials should be between 80 and 120% for all constituents.

Table B-5. Trace Metals: Laboratory Performance Requirements for Analysis of Water Quality Samples for Trace Metals

Analyte	**Method [1]**	**MDL[2], µg/L**	**RL[3], µg/L**	**Accuracy[4], *X***	**Precision[5], *s***	**MS Rec[6]**	**MS/MSD RPD[7]**
Aluminum	EPA 200.8	.06	0.1	80-120	20	80-120	20
Beryllium	EPA 200.8	.7	10	80-120	20	80-120	20
Boron	EPA 200.8	0.1	0.5	80-120	20	80-120	20
Chromium	EPA 200.8	0.2	0.5	80-120	20	80-120	20
Copper	EPA 200.8	0.3	0.5	80-120	20	80-120	20
Lead	EPA 200.8	0.04	0.25	80-120	20	80-120	20
Mercury	EPA 1631[8]	0.15	0.15	75-125	25	75-125	25
Methyl-mercury	EPA 1630[8]	0.025	0.025	75-125	25	75-125	25
Selenium	EPA 200.8	0.02	0.1	80-120	20	80-120	20

(1) SOP or EPA Method number
(2) Method Detection Limit
(3) Target Project Reporting Limit
(4) X = Average recovery for demonstration of initial performance
(5) s = standard deviation of recovery for demonstration of initial performance
(6) Percent recovery of matrix spike
(7) Relative percent difference of matrix spike duplicates
(8) Mercury and methyl-mercury analytical methods may be modified by laboratory in accordance with USEPA performance-based analytical performance criteria

Table B-6 Pesticides: Analytical Methods and Estimated Reporting Limits

Analyte	RL[1]	Analyte	RL[1]
Organophosphorus pesticides by EPA Method 614/8141			
Azinphosmethyl	1.0	Fenthion	0.10
Bolstar	0.10	Malathion	0.10
Chlorpyrifos	0.05	Merphos	0.10
Coumaphos	0.20	Mevinphos	0.70
Def	0.10	Naled	0.50
Demeton-S	0.20	Parathion, ethyl	0.10
Diazinon	0.05	Parathion, methyl	0.10
Dichlorovos	0.20	Phorate	0.10
Dimethoate	0.10	Prowl	0.10
Disulfoton	0.10	Ronnel	0.10
EPN	0.10	Stirophos	0.10
EPTC	0.10	Tokuthion	0.10
Ethion	0.10	Trichloronate	0.10
Ethoprop	0.10	Trifluralin	0.10
Fensulfotion	0.50		
Carbamate pesticides by EPA Method 632/8032			
Aldicarb	0.8	Linuron	0.8
Aminocarb	0.8	Methiocarb	0.8
Barban	7.0	Methomyl	7.0
Benomyl (Carbendazim)	0.8	Mexacarbate	0.8
Bromacil	0.8	Monuron	0.8
Carbaryl	0.14	Neburon	0.8
Carbofuran	0.14	Oxamyl	7.0
Chloropropham	7.0	Propachlor	7.0
Chloroxuron	0.8	Propoxur	0.8
Diuron	0.8	Siduron	0.8
Fenuron	0.8	Tebuthiuron	0.8
Fluometuron	0.8		
Chlorinated pesticides by EPA Method 608/8081			
Aldrin	0.005	Lindane	0.01
BHC-beta isomer	0.01	o,p'-DDD	0.01
Cis-Chlordane	0.01	o,p'-DDE	0.01
Dieldrin	0.01	o,p'-DDT	0.01
Endrin	0.01	p,p'-DDD	0.01
Heptachlor epoxide	0.01	p,p'-DDE	0.01
Heptachlor	0.01	p,p'-DDT	0.01
Hexachlorobenzene (HCB)	0.01		

(1) Reporting Limit for project, based on detection limits achievable by analyzing laboratory. Because detection limits are affected by differences in sample matrices, the RLs listed are estimates.

Table B-7. General Constituents: Analytical Methods and Project Reporting Limits

Constituent	Fractions	Method # (1)	RL, mg/L (2)
Suspended solids	Total	EPA 160.2	5
Hardness	Total, as CaCO3	EPA 130.2	5
Turbidity	Total	EPA 180.1	1.0 NTU
Dissolved solids	Dissolved	EPA 160.1	5
Nitrate	Total	EPA 300	0.05
Organic Carbon	Total, Dissolved	SM 5310 C	0.2
Color	Filtered	EPA 110.1	NA

(1) Standard Methods (SM), EPA Method number, or reference.
(2) Reporting Limit for project, based on detection limits achievable by analyzing laboratory

4.2 Pathogen Analyses

Water quality samples will be analyzed for fecal and total coliform bacteria, and *E. coli*. Analysis for coliform bacteria must be performed in accordance with the methods referenced in Table B-8. The laboratory must demonstrate the ability to meet the performance requirements described in this method.

Table B-8. Pathogen Indicators: Analytical Methods and Estimated Reporting Limits

Constituent	Method (1)	RL (2)
Total Coliform	SM 9221B	2 MPN/100 mL
Fecal Coliform	SM 9221E	2 MPN/100 mL
E. coli	SM 9221B/E mod. MUG	2 MPN/100 mL

(1) Standard Methods (SM) number or method reference.
(2) Reporting Limit for project.

4.3 Aquatic Toxicity Analyses

Water quality samples will be analyzed for short-term chronic toxicity using both the fathead minnow (P*imephales promelas*) and the water flea (*Ceriodaphnia dubia*). All samples are to be initially tested at the 100% solution concentration. Determination of chronic toxicity shall be performed generally as described in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms* (USEPA 1994).

5. Quality Control Requirements

The types of quality control assessments used in the Yolo Bypass Monitoring Program are discussed below. Quality control requirements and schedules are summarized in Tables B-9a through B-9g. Detailed procedures for preparation and analysis of quality control samples are provided in the analytical method documents. A project quality control schedule for the Yolo Bypass project is provided in Table B-10.

5.1 Qualitative Objectives

Comparability

Comparability of the data can be defined as the similarity of data generated by different monitoring programs. For the purpose of the Yolo Bypass Monitoring Program, this objective is addressed primarily by using standard sampling and analytical procedures where possible. Additionally, comparability of analytical data is addressed by analysis of standard reference materials (discussed subsequently in this document).

Representativeness

Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. For the Yolo Bypass, this objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Each of these elements of the quality assurance program are addressed elsewhere in this document.

Completeness

Data completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Completeness is usually expressed as a percentage value. A project objective for percent completeness is typically based on the percentage of the data needed for the program or study to reach valid conclusions. Because this is a one year long monitoring program with monthly sample collection, data that are not successfully collected for a specific sample event or site can not be recollected at a later sampling event. For this reason, most of the data planned for collection are considered absolutely critical. Therefore, program personnel will strive for a 100% completion rate for the 12 months of collection. The program goals for data completeness are based on the planned sampling frequency and a subjective determination of the relative importance of the monitoring element within the Monitoring Program. As shown in Tables B-9b – B-9f, the acceptable completeness is set at 90% for laboratory sample analysis, to account for circumstances beyond the control of field personnel, such as Bypass flooding or loss of samples in shipping. The acceptable completeness for field measurements is set at 95%, as shown in Table B-9g.

5.2 Field Procedures

For basic water quality analyses, quality control samples to be prepared in the field will consist of field blanks and field duplicates. The number of field duplicates and field blanks are set to achieve an overall rate of at least 10% of all analyses for a particular parameter. The external QA samples are rotated among sites and events to achieve the overall rate of 10% field duplicate samples and 10% field blanks (as appropriate for specific analyses).

Field Blanks

The purpose of analyzing field blanks is to demonstrate that sampling procedures do not result in contamination of the environmental samples. Field blanks will be prepared and analyzed for all analytes of interest at the rate of one per sample event, along with the associated environmental samples. Field blanks will consist of laboratory-prepared blank water processed through the sampling equipment using the same procedures used for environmental samples. If any analytes of interest are detected at levels greater than the Reporting Limit (RL) for the parameter, the sampling crew should be notified so that the source of contamination can be identified (if possible) and corrective measures taken prior to the next sampling event. If the concentration in the associated samples is less than five times the value in the field blank, the results for the environmental samples may be unacceptably affected by contamination and should be qualified as an *upper limit* (UL) at the reported value.

Field Duplicates

The purpose of analyzing field duplicates is to demonstrate the precision of sampling and analytical processes. Field duplicates will be prepared at the rate of one per sampling event, and analyzed along with the associated environmental samples. Field duplicates will consist of two aliquots from the same composite sample, or of two grab samples collected in rapid succession. If the relative Percent Difference (RPD) of field duplicate results is greater than 25% and the absolute difference is greater than the RL, both samples should be reanalyzed. If an RPD greater than 25% is confirmed by reanalysis, environmental results will be qualified as *estimated*. The sampling crew should be notified so that the source of sampling variability can be identified (if possible) and corrective measures taken prior to the next sampling event.

5.3 Laboratory Analyses

For basic water quality analyses, quality control samples prepared in the contract laboratory(s) will typically consist of equipment blanks, method blanks, standard reference materials, laboratory duplicates, matrix spikes, and matrix spike duplicates. Laboratory analyses for bacteria will include negative and positive quality control samples, as specified in the method documents.

Equipment Blanks

The purpose of analyzing equipment blanks is to demonstrate that sampling equipment is free from contamination. Prior to using sampling equipment for the collection of environmental samples, the laboratory responsible for cleaning and preparation of the equipment will prepare bottle blanks and sampler blanks. These will be prepared and analyzed at the rate of one each per batch of bottles or sampling equipment. The blanks will be analyzed using the same analytical methods specified for environmental samples. If any analytes of interest are detected at levels greater than the MDL, the source(s) of contamination should be identified and corrected, the

affected batch of bottles or equipment should be re-cleaned, and new equipment blanks should be prepared and analyzed.

Bottle blanks will consist of one of each type of sample container required for water quality analyses, selected randomly from the set of available bottles. The bottles will be filled with laboratory-prepared blank water (acidified to pH < 2 for metals samples) and allowed to stand for a minimum of 24 hours before analysis.

Sampler blanks will consist of laboratory-prepared blank water processed through the sampling equipment using the same procedures used for environmental samples.

Note that these procedures will not be necessary if grab samples are collected by direct submersion of sample bottles, without intermediate sampling equipment.

Method Blanks

The purpose of analyzing method blanks is to demonstrate that the analytical procedures do not result in sample contamination. Method blanks will be prepared and analyzed by the contract laboratory at a rate of at least one for each analytical batch. Method blanks will consist of laboratory-prepared blank water processed along with the batch of environmental samples. The method blank should be prepared and analyzed before analysis of the associated environmental samples. If the result for a single method blank is greater than the MDL, or if the average blank concentration plus two standard deviations of three or more blanks is greater than the RL, the source(s) of contamination should be corrected, and the associated samples should be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified as an *upper limit* (UL) at the reported value.

Laboratory Control Samples

The purpose of analyzing laboratory control samples is to demonstrate the accuracy of the analytical method. Laboratory control samples will be analyzed at the rate of one per sample batch. Laboratory control samples will consist of laboratory fortified method blanks. If recovery of any analyte is outside the acceptable range for accuracy, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and the laboratory control sample should be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified as *low or high biased*.

Laboratory Duplicates

The purpose of analyzing laboratory duplicates is to demonstrate the precision of the analytical method. Laboratory duplicates will be analyzed at the rate of one pair per sample batch. Laboratory duplicates will consist of duplicate laboratory fortified method blanks. If the RPD for any analyte is greater than the precision criterion *and* the absolute difference between duplicates is greater than the RL, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and laboratory duplicates should be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified as *not reproducible* due to analytical variability.

Matrix Spikes and Matrix Spike Duplicates

The purpose of analyzing matrix spikes and matrix spike duplicates is to demonstrate the performance of the analytical method in a particular sample matrix. Matrix spikes and matrix spike duplicates will be analyzed at the rate of one pair per sample batch. Each matrix spike and matrix spike duplicate will consist of an aliquot of laboratory-fortified environmental sample. Spike concentrations should be added at between 2 to 10 times the expected sample value.
If matrix spike recovery of any analyte is outside the acceptable range, the results for that analyte have failed the acceptance criteria. If recovery of laboratory control samples is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. Attempt to correct the problem (by dilution, concentration, etc.) and re-analyze the samples and the matrix spikes. If the matrix problem can't be corrected, qualify the results for that analyte as appropriate (*low or high biased*) due to matrix interference.

If matrix spike duplicate RPD for any analyte is greater than the precision criterion, the results for that analyte have failed the acceptance criteria. If the RPD for laboratory duplicates is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. Attempt to correct the problem (by dilution, concentration, etc.) and re-analyze the samples and the matrix spike duplicates. If the matrix problem can't be corrected, qualify the results for that analyte as *not reproducible*, due to matrix interference.

Aquatic Toxicity Quality Control

For aquatic toxicity tests, the acceptability of test results is determined primarily by performance-based criteria for test organisms, culture and test conditions, and the results of control bioassays. Control bioassays include testing with reference toxicants, and negative and solvent controls.

In addition to the QA requirements for the toxicity testing methods, a minimum of ten percent of the samples collected for aquatic toxicity testing will be reserved for other QC analyses. These analyses will consist of interlaboratory splits, field duplicates, or spiked samples. At least one laboratory split analyses will be performed during the monitoring year, *if possible*. If no appropriate laboratories are willing to perform these analyses at a reasonable cost, these QA samples will be analyzed as field duplicates by Aqua Science. Field duplicate samples analyzed for aquatic toxicity will also serve as field duplicates for alkalinity and hardness analyses. Although the laboratory has no formal limit of acceptability for analysis of spiked samples, the pattern and progress of toxic responses are evaluated subjectively for consistency with expected responses for the level of the spiked compound. Acceptable results for tests with blanks are no significant toxicity.

Table B-9a. Project Quality Control Requirements for Analysis of Water Quality Samples: Frequency[1] and Numbers of Field Quality Assurance Samples for Mercury, Organic Carbon, General Water Quality Constituents, Pesticides, and Pathogen Indicators.

Parameter(s)	Field Duplicates	Field Blanks	Total QA Samples
Mercury	12 (1 per event)	12 (1 per event)	24
Methylmercury	12 (1 per event)	12 (1 per event)	24
Hardness	6 (1 per event)	0	6
TOC and DOC	6 (1 each per event)	6 (1 per event)	12
Color	6 (1 per event)	0	6
TSS	6 (1 per event)	0	6
TDS	6 (1 per event)	0	6
Nitrate	6 (1 per event)	6 (1 per event)	12
OP Pesticides	6 (1 per event)	6 (1 per event)	12
Carbamate Pesticides	6 (1 per event)	6 (1 per event)	12
Chlorinated Pesticides	6 (1 per event)	6 (1 per event)	12
Trace Metals	6 (1 per event)	6 (1 per event)	12
Fecal coliform	12 (1 per event)	12 (1 per event)	24

(1) External QA samples are rotated among sites to provide at least one field duplicate sample and one field blank per event for a particular parameter (as appropriate for specific analyses).

Table B-9b. Project Quality Control Requirements for Analysis of Water Quality Samples: Trace Metals, Organic Carbon, and General Water Quality Constituents.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle lot, reagent lot, or equipment lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	Various, see Table B-8a	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	Various, see Table B-8a	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Method Blank	Contamination	≥1 per batch, (trace metals and OC)	< MDL *or*, if n≥3, avg ± 2 s.d. < RL	Identify contamination source. Reanalyze method blank and all samples in batch.
LCS or SRM	Accuracy	1 per batch	80-120% REC	Recalibrate and reanalyze LCS or SRM and samples
Lab Duplicate	Precision	1 per batch	RPD ≤ 20% if |Difference| ≥ RL	Recalibrate and reanalyze.
Matrix Spike	Accuracy	1 per batch	80-120% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 20%	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term "lot" refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term "batch", as used in this document, refers to an uninterrupted series of analyses.

Table B-9c. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Chlorinated Pesticide Analyses by EPA Method 608.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < (sample ÷ 5)	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS	Accuracy	1 per batch	28-163% REC 60-117% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: BHC-alpha isomer BHC-beta isomer Cis-Chlordane Dieldrin Endrin Heptachlor epoxide Heptachlor Hexachlorobenzene (HCB) Lindane o,p'-DDD o,p'-DDE o,p'-DDT p,p'-DDD p,p'-DDE p,p'-DDT Trans-chlordane	Precision	1 per batch	31% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term "lot" refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term "batch", as used in this document, refers to an uninterrupted series of analyses.

Table B-9d. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Organophosphorus Pesticide Analyses by EPA Method 614.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < (sample ÷ 5)	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion Tributylphosphate Triphenlyphosphate	Accuracy	1 per batch	 22-96% REC 57-130% REC 47-117% REC 55-164% REC 68-128% REC 65-134% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion	Precision	1 per batch	 24% RPD 21% RPD 22% RPD 24% RPD 25% RPD 20% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term "lot" refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term "batch", as used in this document, refers to an uninterrupted series of analyses.

Table B-9e. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Carbamate Pesticide Analyses by EPA Method 632.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < (sample ÷ 5)	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Methomyl Bromacil Neburon Oryzalin	Accuracy	1 per batch	 37-113% REC 58-111% REC 55-132% REC 40-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Methomyl Bromacil Neburon	Precision	1 per batch	 25% RPD 25% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term "lot" refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term "batch", as used in this document, refers to an uninterrupted series of analyses.

Table B-9f. Project Quality Control Requirements for Analysis of Water Quality Samples for Pathogens and Pathogen Indicators.

QA Procedure	Parameter	Frequency[1]	Criterion	Corrective Action
Field Blanks	Contamination	1 per event	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Method Blanks (Sterility Checks)	Contamination	1 per batch	< RL	Identify contamination source. Clean equipment and slides. Check reagents. Re-analyze blank.
Lab Duplicate	Precision[2]	1 per 10 samples, and at least 1 per batch	$R_{log} \leq 3.27 \bullet$mean R_{Log}	Recalibrate and reanalyze.
Negative Control Samples	Contamination	1 per culture medium or reagent lot	< RL	Identify source. Clean equipment and prepare new media. Re-examine negative control
Positive Control Samples	Assay function	1 per culture medium or reagent lot	≥ RL	Identify and correct problem. Re-examine positive control.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The method documentation defines an analytical batch as an "uninterrupted series of analyses".

(2) R_{log} is the absolute difference between logarithms of coliform counts for duplicate analyses. The mean R_{log} is determined by performing duplicate analyses on the first 15 positive sample analyzed for each matrix type.

Table B-9g. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Field Measurements.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Field Duplicate	Precision	1 per event	RPD ≤ 25%	Reanalyze both samples. Identify variability source. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	95%	Reschedule sample events as necessary or appropriate.

Notes: RPD = Relative Percent Difference;

Table B-10. Project Quality Control Schedule

SITE	EVENTS											
	Nov **1**	Dec **2**	Jan **3**	Feb **4**	March **5**	April **6**	May **7**	June **8**	July **9**	Aug **10**	Sept **11**	Oct **12**
1												
2	FB/FD									MS/MSD		
3		FB/FD							MS/MSD			
4			FB/FD					MS/MSD				
5				FB/FD			MS/MSD					
6					FB/FD	MS/MSD					MS/MSD	
7					MS/MSD	FB/FD					FB/FD	
8												
9				MS/MSD			FB/FD					
10			MS/MSD					FB/FD				
11		MS/MSD							FB/FD			MS/MSD
12	MS/MSD									FB/FD		FB/FD

FB = Field Blank

FD = Field Duplicate

MS/MSD = Matrix Spike/Matrix Spike Duplicate

5.4 Sample Equipment Cleaning Procedures

Equipment used for sample collection (peristaltic pump tubing, carboys and carboy caps, and sample bottles) will be cleaned according to the specific procedures documented for each analytical method.

A minimum of one equipment blank will be generated and analyzed for mercury and methylmercury prior to initiating monitoring for the current program year, and additional equipment blanks will be analyzed for new lots of critical cleaning reagents. In addition, for all analytes where contamination is considered a significant concern, field blanks will be collected and analyzed as directed in Section B-5 of this document. If the results of these analyses indicate any contamination, the source will be identified and corrected, and the equipment will be re-cleaned and re-tested. The combined regimen of equipment blanks and field blanks is considered to provide adequate control against potential systematic equipment contamination problems.

5.5 Analytical Instrument and Equipment Testing Procedures and Corrective Actions

Testing, inspection, maintenance of analytical equipment used by the contract laboratory, and corrective actions are documented in the Quality Assurance manuals for each analyzing laboratory. Laboratory QA Manuals are made available for review at the analyzing laboratory.

6. Calibration Procedures and Frequency

6.1 Laboratory Analytical Equipment

Frequency and procedures for calibration of analytical equipment used by each contract laboratory is documented in the Quality Assurance Manual for each contract laboratory. Laboratory QA Manuals are made available for review at the analyzing laboratory.

6.2 Field Instruments

Calibration of all instruments used for measurement of field parameters (temperature, pH, dissolved oxygen, and electroconductivity) are performed as described in the owner's manuals for individual instruments. Instruments used to measure pH, dissolved oxygen, and electroconductivity should be calibrated prior to taking field measurements at each site for each event. Typical field instrument calibration procedures are as follows:

- Temperature calibration is factory-set and requires no subsequent calibration.
- Calibration for pH measurement is accomplished using standard buffer solutions.
- Calibration for dissolved oxygen measurements is accomplished using an oxygen-saturated water sample.
- Calibration for electroconductivity measurements is generally accomplished using potassium chloride standard solutions.

7. Inspection/Acceptance Requirements for Supplies and Consumables

Gloves, sample containers, and any other consumable equipment used for sampling will be inspected by the sampling crew on receipt and will be rejected/returned if any obvious signs of contamination (torn packages, etc.) are observed. Inspection protocols and acceptance criteria for laboratory analytical reagents and other consumables are documented in the Quality Assurance Manuals for individual laboratories. Laboratory QA Manuals are made available for review at the analyzing laboratories.

8. Quality Control Requirements for Indirect Measurements

Water quality data collected by this monitoring program is intended to complement data collected by several other programs, including NAWQA, and receiving water monitoring conducted by the City of Woodland, the City of Davis, and the University of California at Davis.

9. Data Management

Copies of field logs, copies of chain of custody forms, original preliminary and final lab reports, and electronic media reports will be sent to the Quality Assurance Manager. Each type of report will be stored separately and ordered chronologically. The field crew will retain original field logs. The contract laboratory will retain original chain of custody forms. The contract laboratory(s) will retain copies of the preliminary and final data reports.

Concentrations of chemicals and toxicity endpoints, and all numerical biological parameters will be calculated as described in the laboratory Standard Operating Procedures or referenced method document for each analyte or parameter.

The various data and information generated from the Yolo Bypass Monitoring Program will be stored and maintained at the Monitoring Program Manager's offices (Larry Walker Associates). The data generated from the monitoring program will be transmitted to the Quality Assurance Manager in various formats and converted to a standard database format maintained on personal computers in the Monitoring Program Manager's office. After data entry or data transfer procedures are completed for each sample event, data will be inspected for data transcription errors, and corrected as appropriate. After the final QA checks for errors are completed, the data are added to the final database. Data tables are generated from this database.

In cases where a laboratory reports an environmental result that is less than the reporting limit for a parameter, the result will be reported as shown on the lab report, with a note indicating that the result is lower than the reporting limit, and as such the result is estimated. For results reported as "non-detect", the result will be reported as less than the reporting limit; e.g., <5 µg/L.

In cases where field blank results exceed the acceptance criteria listed in Table B-0.1, data collected during the associated sample run will be qualified and reported as follows:

- Measured environmental sample concentrations greater than or equal to 5 times the field blank level will be reported with no qualification.
- Measured environmental sample concentrations less than 5 times the field blank level will be qualified as "less than" the measured value, e.g. if a field blank is equal to 1.5 µg/L, a measured environmental concentration of 4.0 µg/L will be reported as <4.0 µg/L.
- Any data qualifications resulting from QC analyses will be reported with the environmental data as appropriate.

C. ASSESSMENT AND OVERSIGHT

1. Assessments and Response Actions

Assessments of compliance with quality control procedures will be undertaken on a routine basis during the data collection phase of the project:

- Performance assessments of sampling procedures will be performed by the field sampling crews. Corrective actions shall be carried out by the field sampling crew and reported to the Quality Assurance Manager.
- Assessment of laboratory QC results and implementation of corrective actions will be the responsibility of the QA officer at each laboratory and shall be reported to the Quality Assurance Manager as part of any data reports.
- Assessment of field QC results and implementation of corrective actions shall be the responsibility of the Quality Assurance Manager.

Routine procedures to assess precision and accuracy, criteria for success, and corrective actions have been discussed previously (Section B) and are summarized in Table B-9a through B-9f.

Monthly status reports will be produced by the Monitoring Program Manager to document project status, results of performance evaluations, data quality assessments, and any significant QA problems and recommended solutions. Monthly status reports will be distributed to the Project Manager and the CalFed liaison officer.

2. Quality Assurance Reports to Management

On completion of the monitoring season, a quality assurance report will be prepared by the Quality Assurance Manager, as part of the annual report produced for the Yolo Bypass. The quality assurance report will summarize the results of QA/QC assessments and evaluations, including precision, accuracy, comparability, representativeness, and completeness of the monitoring data. The annual report will be distributed to the project managers, stakeholder group members, and interested parties.

D. DATA VALIDATION AND USABILITY

1. Data Review, Validation, and Verification

In addition to the data quality objectives presented in Tables B-9a through B-9f, the standard data validation procedures documented in the contract laboratory's Quality Assurance Manuals will be used to accept, reject, or qualify the data generated by the laboratory. Laboratory's QA officer will be responsible for validating data generated by the laboratory. The field monitoring coordinator will be responsible for initial verification of data submitted by analyzing labs, including electronic data reports. The Quality Assurance Manager will be responsible for final validation and for qualifying all data based on the evaluation of field and laboratory quality control samples.

Mercury and methyl-mercury data shall be reviewed to evaluate whether the data are reasonable; i.e, methyl-mercury concentrations should not exceed the corresponding total mercury concentrations.

2. Data Reporting

Laboratory personnel will verify that the measurement process was "in control" (i.e., all specified data quality objectives were met or acceptable deviations explained) for each batch of samples before proceeding with the analysis of a subsequent batch. In addition, each laboratory will establish a system for detecting and reducing transcription and/or calculation errors prior to reporting data.

The laboratory will only consider submitted data that have met data quality objectives, or have acceptable deviations explained. When QA requirements have not been met, the samples will be reanalyzed when possible and only the results of the reanalysis will be submitted, provided they are acceptable.

For mercury and methyl-mercury, all laboratory QA information will be reported along with the analytical results.

E. REFERENCES

APHA, AWWA, and WEF 1995. Standard Methods for the Examination of Water and Wastewater, 19th Edition. American Public Health Association (APHA), American Waterworks Association (AWWA), and Water Environment Association (WEF). Washington, DC.

USEPA 1979. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. U.S. Environmental Protection Agency (USEPA). EPA 600-4-79-019.

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USEPA 1994. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms (EPA 600/4-91-002). U.S. Environmental Protection Agency (USEPA), Office of Research and Development. July 1994.

USEPA 1995. Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring. EPA 821-B-95-002. U.S. Environmental Protection Agency, Office of Water, Washington DC.

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USEPA 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R-95-034.

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