Delta Regional Monitoring Program

Monitoring Design Summary

DELTA RMP
Regional Monitoring Program

Technical Advisory Committee

AQUATIC SCIENCE CENTER

Prepared for

Delta RMP Steering Committee
November 3, 2014
Revised May 30, 2018

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1 Overview

This document summarizes the initial draft design of the Delta Regional Monitoring Program (Delta RMP) for review and confirmation by the Steering Committee.

The recommendations presented here reflect input from subgroups of the Delta RMP Technical Advisory Committee (TAC). The purpose of this summary is to provide a basis for the Steering Committee and TAC to prioritize initial activities, coordinate with other monitoring programs, and help establish institutional and funding agreements.

The Steering Committee has expressed that the study design and data evaluation should always take into consideration co-variance of influencing factors such as flows and hydrodynamics, invasive species (e.g. grazing by non-native bivalves), organic carbon, salinity, temperature, and turbidity.

Four distinct designs are provided, one for each of the initial priority constituents: Pathogens, Current Use Pesticides, Mercury, and Nutrients. Each summary includes:

- Initial assessment questions
- Study design
- Monitoring sites (named and mapped)
- Example data products
- Target parameters

2 Assessment Questions

The Delta RMP has agreed upon a set of management questions that reflect specific concerns about multiple aspects of the Delta and the impacts of human activities. The purpose of this Monitoring Design is to outline the monitoring programs or special studies that would be needed to start to answer these questions.

Since each of the management questions is quite broad, it was important to first identify a set of more specific “assessment questions” to guide the monitoring design. Table 1 lists the management questions that were developed by the Steering Committee and the assessment questions that were developed by the Current Use Pesticides, Mercury, Nutrients, and Pathogens subcommittees and the TAC. The monitoring designs were developed to generate data and information products to answer the assessment questions and, ultimately, the management questions.

Table 1. Delta RMP management and assessment questions. Questions highlighted in yellow are the highest priority for initial studies.

Type	Core Management Questions	Mercury	Pesticides	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. Do trends over time in MeHg in **water** similar or different among Delta subareas?	1. To what extent do current use pesticides contribute to observed toxicity in the Delta? 1.1. Which pesticides or degradates have the highest potential to be causing toxicity in the Delta and therefore should be the priority for monitoring and management? A. If samples are toxic, do detected pesticides explain the toxicity? B. If samples are not toxic, do detected pesticide concentrations exceed other thresholds of concern (e.g., water quality objectives or Office of Pesticide Programs aquatic toxicity benchmarks)? 1.2. What are the spatial and temporal extents of lethal and sublethal aquatic and sediment toxicity observed in the Delta? A. Do aquatic or sediment toxicity tests at targeted sites indicate a toxic response? B. If answer to A is yes, which other toxicity indicator(s) should guide monitoring and management of pesticides in Years 2+? 2. What are the spatial/temporal distributions of concentrations of currently used pesticides identified as likely causes of observed toxicity? 2.1. Which pesticides have the highest risk potential	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?	1. A B

Type	Core Management Questions	Mercury	Pesticides	Nutrients	
			(based on DPR's risk prioritization model[1]) and should be included in chemical analyses? A. Is the list of pesticides included in USGS pesticide scan sufficient for Delta RMP monitoring design? B. Are methods available to monitor pesticides with high-risk potential not included in USGS pesticide scan? 2.2. How do concentrations of the pesticides with the highest risk potential vary seasonally and spatially?		
Sources, Pathways, Loadings & Processes	Which sources and processes are most important to understand and quantify? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?	1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish? A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)? B. How do internal sources and processes influence methylmercury levels in fish in the Delta? C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels	1. What are the principal sources and pathways responsible for aquatic and sediment toxicity observed in the Delta? 2. What are the fates of prioritized pesticides and degradates in the environment? 2.1. Do physical/chemical properties of priority pesticides, application rates and processes, and ambient conditions influence the degree of toxicity observed? 3. What are the spatial/temporal use patterns of priority pesticides?	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. What are the types and sources of nutrient sinks within the Delta? F. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water	1. C le ic o A. B. C. 2. W a ra q fc

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

[2] EPA has developed the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 rule), which classifies filtered water systems into one of four treatment categories (bins) based on their monitoring results for *Cryptosporidium*. Most systems are expected to be classified in the lowest bin and will face no additional requirements. Systems classified in higher bins must provide additional water treatment to further reduce *Cryptosporidium* levels by 90 to 99.7 percent (1.0 to 2.5-log), depending on the bin. From: Rule Fact Sheet - Long Term 2 Enhanced Surface Water Treatment Rule (USEPA 2005).

Type	Core Management Questions	Mercury	Pesticides	Nutrients	
		in fish in the Delta?		intakes for the State and Federal Water Projects? 2. How are nutrients linked to water quality concerns such as harmful algal blooms, low dissolved oxygen, invasive aquatic macrophytes, low phytoplankton productivity, and drinking water issues? A. Which factors in the Delta influence the effects of nutrients on the water quality concerns listed above?	
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?	1. How do pesticide concentrations respond to different management scenarios? 2. What current use pesticide loads can the Delta assimilate without exceeding water quality criteria established to protect beneficial uses? 3. How will climate change affect concentrations and/or loadings of pesticides and impacts to aquatic species?	1. How will nutrient loads, concentrations, and water quality concerns from Sources, Pathways, Loadings & Processes Question 2 respond to potential or planned future source control actions, restoration projects, water resource management changes, and climate change?	1. 2.
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?	[none]	4. Are pesticide-related toxicity impacts decreasing over time?	1. How did nutrient loads, concentrations, and water quality concerns from Sources, Pathways, Loadings & Processes Question 2 respond to source control actions, restoration projects, and water resource management changes?	

3. Recommended Monitoring Designs

The proposed initial designs focus on status and trends questions. This overview document only considers the *recommended* design for each constituent. The attached four constituent monitoring design summaries provide additional options with associated costs to provide a range of designs based on available funding. The recommended designs, by constituent, are summarized below. **Figure 1** shows a map of the proposed sampling sites for each constituent and, for reference, the potential Delta RMP core sites proposed by POTWs.

Current Use Pesticides

Water

Baseline Sites

Monthly sampling at five sites, which would also capture targeted events. Targeted events (n = 5/year): Wet Weather: (1) 1st seasonal flush (Water Year), (2) Significant winter storm; Dry weather: (1) Early Spring, (2) Late spring/early summer irrigation season, (3) Late summer irrigation season. Chemical analyses and toxicity testing on all samples. Proposed test species (endpoints): (1) *Selenastrum capricornutum* (growth) (2) *Ceriodaphnia dubia* (survival and reproduction), (3) *Hyalella azteca* (survival), and (4) *Pimephales promelas* (larval survival and growth) and/or *Oncorhynchus mykiss* (larval survival). Chemistry: pesticide scan (USGS), total suspended solids, dissolved organic carbon (DOC) and particulate organic carbon (POC), hardness, and dissolved copper analysis. Pesticide-focused Toxicity Identification Evaluations (TIEs) for a subset of samples with $\geq$ 50% of the measured endpoint; to be decided real-time by a TIE subcommittee.

Additional "targeted" sites

Three to four targeted sites for event-based sampling only. Addition of these sites is recommended for increasing the spatial coverage of current use pesticides monitoring. Ideally, these sites would also be sampled monthly. The events only based sampling at these sites represents a compromise driven by budget considerations. In principle, there is no difference between baseline sites and these additional sites targeted for event-based sampling only. However, the 5 recommended baseline sites were considered higher priority for more frequent sampling than the 3-4 additional sites.

Sediment

No additional monitoring. The Delta RMP will include data from the Surface Water Ambient Monitoring Program (SWAMP) Stream Pollution Trends (SPoT) monitoring (State Water Resources Control Board) in the initial assessment. SPoT collects samples in the Delta region annually in late summer. SpoT toxicity test species (endpoints): (1) *Hyalella azteca* (survival), (2) *Chironomus dilutus/tentans* (survival). Chemistry: pyrethroids, and other pesticides, such as fipronil.

Mercury

Sport Fish

Annual sampling is proposed at 10 fixed sites in late summer to early autumn. Indicator of primary interest is methylmercury in muscle fillet of 350-mm largemouth bass (or similar predator species). Sites will be located to represent different subareas of the Delta and to link with water monitoring.

Water

Monthly sampling at five sites that align with sport fish monitoring sites. Indicator of primary interest is total methylmercury in water (measured as sum of particulate and dissolved).

Important ancillary parameters include particulate and dissolved total Hg, nutrients, chlorophyll, DOC/POC, grain size, suspended sediment, POC. Budget assumes nutrients covered by other funds; other parameters covered by budget in table below.

Nutrients

No monitoring is proposed during the initial phase of program implementation. Instead, the RMP will synthesize and analyze existing information and data, and then design a monitoring plan based on findings and recommendations. The nutrient data analysis and monitoring plan development will be closely coordinated with the development of the Delta Nutrient Research Plan (led by the Central Valley Water Board) and ongoing funded studies that will at least partially address RMP assessment questions. The nutrient data synthesis will focus on the following parameters: ammonium (NH_4), nitrate (NO_3), dissolved inorganic nitrogen (DIN), total dissolved nitrogen (TDN), dissolved organic nitrogen (DON), phosphate (PO_4), chlorophyll a (chl-a), and dissolved oxygen (DO).

Pathogens

Monthly sampling for a two-year special study characterizing pathogen levels (*Cryptosporidium* and *Giardia*) to address the objectives of the Pathogen Special Study required by the Central Valley Drinking Water Policy Basin Plan Amendment. The study includes monitoring at ambient locations throughout the Delta. The sampling will be added to the routine monthly sampling effort of the Department of Water Resources (DWR) Municipal Water Quality Investigations (MWQI). The proposed Delta RMP contribution would be to pay for required additional laboratory analyses, data management, and reporting.

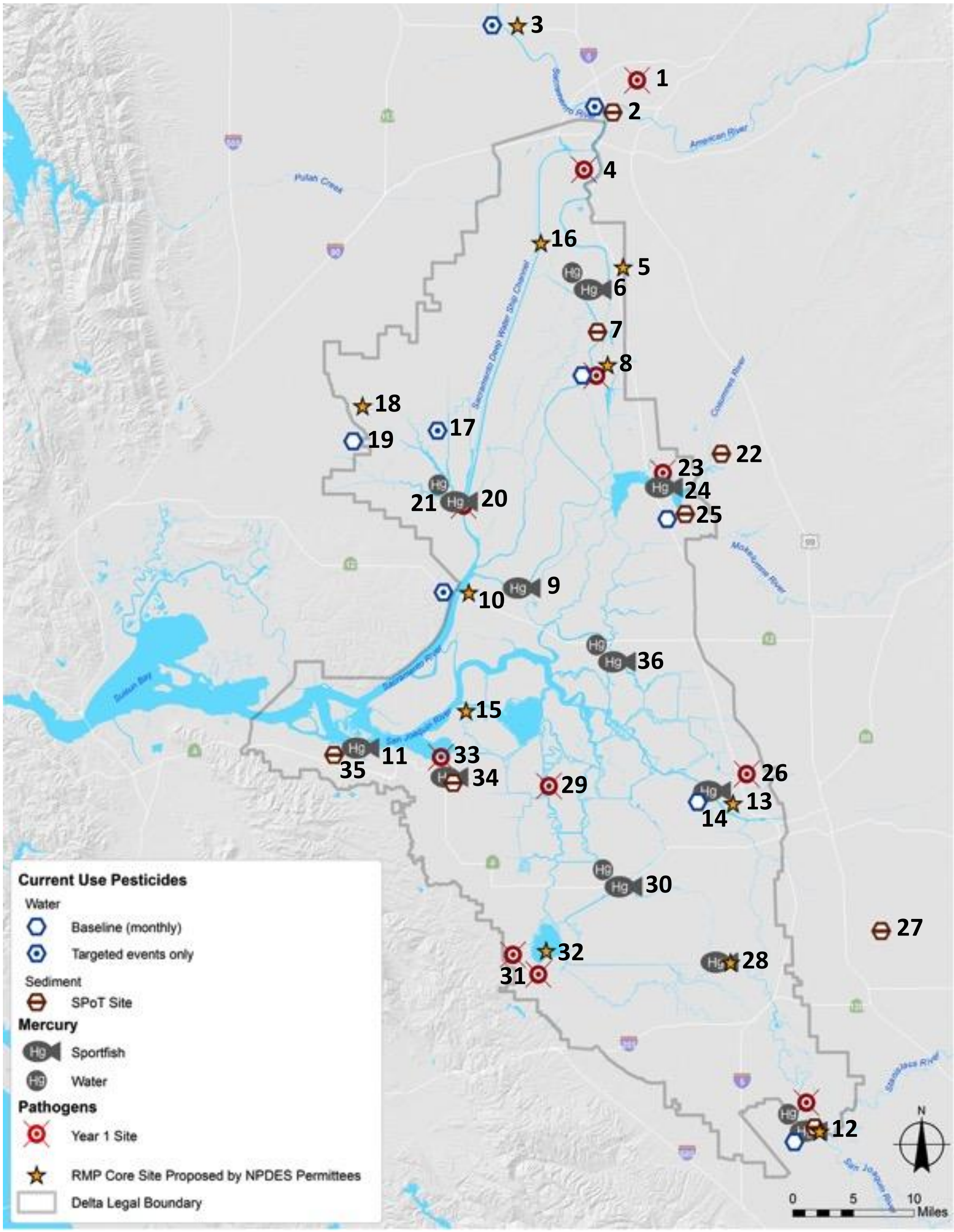


Figure 1. Proposed Delta RMP Monitoring Sites. See Table 2 for more information.

Table 2. List of proposed Delta RMP sites and monitoring frequency, by constituent class.

Proposed Sites	Map Key	Current Use Pesticides - Water Sampling	Current Use Pesticides - SpoT Sediment Sampling	Mercury - Sport Fish	Mercury - Water	Pathogens Special Study
Colusa Basin Ag Drain	*					M
Natomas East Main Drainage Canal	1					M
American R @ Discovery Park	2	E	Y			
Sacramento R @ Veteran's Bridge	3	E				
Sacramento R @ Westin Boat Dock	4					M
Sacramento R @ Freeport	5					
Sacramento R @ RM44	6					
Sacramento R @ Clarksburg Marina	7		Y			
Sacramento R @ Hood	8	M				M
Sacramento R nr Isleton	9			Y		
Sacramento R @ Rio Vista	10	E				
Sherman Lake	11			Y		
San Joaquin R @ Vernalis/Airport Way	12	M	Y	Y	M	M
San Joaquin R @ Rough & Ready Island	13					
San Joaquin R @ Buckley Cove	14	M		Y		
San Joaquin R @ Jersey Pt	15					
Yolo Bypass @ Lisbon	16					
Shag Sl @ Liberty Island Bridge	17	E				
Ulatis C @ Main Prairie Rd	18					
Ulatis C @ Brown Rd	19	M				
Liberty Island south	20					Monthly
Liberty Island	21			Y	M	
Cosumnes R @ Twin Cities Rd	22		Y			
Mokelumne R @ Benson Ferry	23					M
Mokelumne R ds Cosumnes R	24			Y		
Mokelumne R @ New Hope Road	25	M	Y			
Calaveras R @ UoP Footbridge	26					M
Lone Tree C @ Austin Rd	27			Y		
Old R nr Middle R	28			Y		

Proposed Sites	Map Key	Current Use Pesticides - Water Sampling	Current Use Pesticides - SpoT Sediment Sampling	Mercury - Sport Fish	Mercury - Water	Pathogens Special Study
Old R @ Bacon Island	29					M
MID flux station	30			Y	M	
Jones Pumping Plant	31					M
Banks Pumping Plant	32					M
Rock Slough @ CCWD Fish Facility	33					M
Marsh C	34		Y	(Y)		
Kirker C @ Floodway	35		Y			
Little Potato Slough	36			Y	M	

*Outside of map area; M = Monthly, Y = Yearly, E = Events only

3 Coordination Opportunities

The potential for sampling coordination or consolidation and associated cost-savings is more significant for sampling efforts that are more frequent and less specialized than for sampling efforts that are less frequent and require highly specialized equipment and techniques. Examples for more frequent sampling efforts requiring little specialized equipment or techniques are the collection of water grab samples for analyses of pathogens or pesticides or toxicity testing. An example for a very specialized sampling effort is the collection of cross-sectional water samples employing ultra-clean techniques for methylmercury analyses.

Coordination opportunities could be realized by a) co-locating sites or consolidating sampling sites that are in close proximity to each other and provide similar information, b) timing routine sampling schedules such that they cover desired events, and c) collaborative agreements with existing program that sample at sites of interest or nearby or who may be willing to add certain sites to their existing monitoring schedule (and time their sampling such that it would cover desired events).

Specific steps in exploring coordination opportunities will involve:

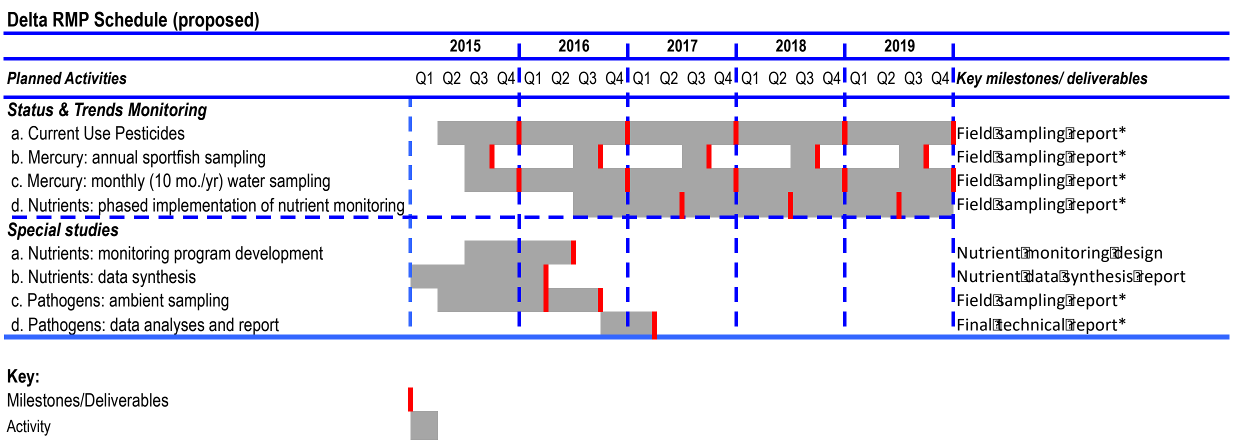
1) Evaluating the technical feasibility of sampling coordination (TAC and ASC),
2) Deciding on and negotiate collaborative sampling arrangements (SC), and
3) Coordination planning (ASC).

Potential partners for sampling coordination (implementation of first year of sampling) have been identified and include the DWR MWQI, U.S. Geological Survey, State Water Resources Control Board, Sacramento Valley Water Quality Coalition, San Joaquin County and Delta Water Quality Coalition, East San Joaquin Water Quality Coalition, and the Westside San Joaquin Watershed Coalition.

4 Schedule

A preliminary proposed five-year schedule for the Delta RMP is shown in Table 3. This schedule assumes no funding constraints. The proposed schedule is a projection that based on the initial priorities and proposed designs and is subject to change. Actual tasks to be completed during the next five years will depend on approval of annual plans by the SC and available funding. The five-year plan should be refreshed each year through a planning process with the TAC and Steering Committee.

Table 3. Proposed, preliminary five-year schedule for the Delta RMP. Status & Trends Monitoring consists of ongoing long-term monitoring; Special Studies are short-term studies designed to answer specific management questions and may also lead to adaptions in Status & Trends monitoring.



*The Field Sampling Report will document how samples were collected, target sampling sites, actual sampling sites, how many samples were collected, measurements made using field instruments, and any deviations from the QAPP for field sampling methods.

5 Budget Estimate

Table 4 provides preliminary program budget estimates that are based on the *recommended* designs for each constituent. The table does not include cost estimates for program management, governance, communications, data management, and reporting. To some extent, those overall components scale relative to the level of effort of proposed monitoring and special studies. However, they would decrease less than proportionally if the level of effort were reduced.

The budget estimate does not yet factor in potential cost savings that could be achieved through sampling coordination, "piggybacking", or no-cost in-kind contributions.

Budget numbers presented here are estimates for planning purposes only. The annual workplan will contain the detailed, operational budgets.

Table 4. Preliminary budget estimates for the full implementation of the initial Delta RMP monitoring design. These estimates do not include costs for program management, data management, or reporting. * = Recommended funding level for first year of sampling (pathogens: first and second year of sampling).

		Funding Level	
Program Element	**Low**	**Medium**	**Higher**
Current Use Pesticides	$477,000	$627,000*	$1,619,000
Mercury			
– Sport fish sampling	$73,000*		$140,000
– Water sampling	$69,000	$138,000*	$165,000
Nutrients			
– Synthesis	$70,000	$110,000	$160,000*
– Monitoring Design	$65,000*		$65,000*
Pathogens (2-yr study)			
– Ambient monitoring (2 yrs)	$72,000	144,000*	$288,000
– Additional special studies		47,250*	
Annual Cost	$826,000	$1,204,250	$2,484,250

6 Data Analysis and Interpretation, Reporting, and Application of Results

The Monitoring Design does not cover the methods for quality assurance, data analysis, interpretation, and reporting. That level of detail is beyond the scope of this report.

Quality assurance methods and details will be included in the Quality Assurance Project Plan for the program.

Interpretation and reporting methods will be described in a Communications Plan. Information generated by the Delta RMP should allow program participants to monitor and assess progress in achieving beneficial use protection throughout the Delta. The planning cycle framework begins with the development and re-evaluation of core monitoring questions and priority topics, then moves into the development and implementation of annual monitoring questions and activities (including monitoring and special studies), and culminates with methods of evaluating and utilizing this information to make adaptive program changes in the next annual or 5-year cycle. The Communications Plan will deal with the data analysis and reporting portion of this cycle.

The Communications Plan will be developed during FY15/16. See the draft outline below.

<u>Communications Plan Outline</u>

1. Data Interpretation
    a. What analyses are needed to answer the management and assessment questions?
        i. Graphical tools
        ii. Spatial analyses
        iii. Statistical tests
2. Data Reporting
    a. How will results be communicated to internal and external stakeholders?
        i. Communication Products
        ii. Internal review process
        iii. External review process
        iv. Public release process
3. Adaptive Management
    a. How will results be used to update the Monitoring Design?
        i. Schedule and process for updating the Monitoring Design

ii. Schedule and process for coordination with other Delta monitoring programs

7 Next Steps

Consistent points made by the constituent subcommittees for next steps towards developing the designs for the initial focus areas (current use pesticides, mercury, nutrients, and pathogens) include:

- Scale monitoring design to match Steering Committee interests and available budget
- Coordinate with potential monitoring partners
- Develop annual workplans covering all aspects of the program (fieldwork and data management; reporting; contracting and bookkeeping, schedule)
- Develop a Quality Assurance Program Plan (QAPP)
- Develop a Communications Plan.

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8 Attachment:

Current Use Pesticides

Specific Monitoring Design Details

DELTA RMP
Regional Monitoring Program

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Specific Monitoring Design Details – Current Use Pesticides

Initial Assessment Questions

The initial Delta RMP priority for current use pesticides is to address the overall Management Question:

Is there a problem or are there signs of a problem?

S&T 1. To what extent do current use pesticides contribute to observed toxicity in the Delta?

- S&T1.1. Which pesticides have the highest potential to be causing toxicity in the Delta and therefore should be the priority for monitoring or management?
  - A. If samples are toxic, do detected pesticides explain the toxicity?
  - B. If samples are not toxic, do detected pesticide concentrations exceed other thresholds of concern (e.g., water quality objectives or Office of Pesticide Programs aquatic toxicity benchmarks)?
- S&T1.2. What are the spatial and temporal extents of lethal and sublethal water column and sediment toxicity observed in the Delta?
  - A. Do water column or sediment toxicity tests at targeted sites indicate a toxic response?
  - B. If answer to A is yes, which other toxicity indicator(s) should guide monitoring and management of pesticides in Years 2+?

S&T 2. What are the spatial/temporal distributions of concentrations of current use pesticides identified as likely causes of observed toxicity?

- S&T2.1. Which pesticides have the highest risk potential (based on DPR's risk prioritization model[3]) and should be included in chemical analyses?
  - A. Is the list of pesticides included in USGS pesticide scan sufficient for Delta RMP monitoring design?
  - B. Are methods available to monitor pesticides with high-risk potential not included in USGS pesticide scan?
- S&T2.2. How do concentrations of the pesticides with the highest risk potential vary seasonally and spatially?

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

Study Design

Water Sampling

- ⇨ Toxicity testing for all samples - Proposed test species (endpoints):
    - *Selenastrum capricornutum* (growth)
    - *Ceriodaphnia dubia* (survival and reproduction)
    - *Hyalella azteca* (survival)[4]
    - *Pimephales promelas* (larval survival and growth) and/or *Oncorhynchus mykiss* (larval survival).
- ⇨ Chemistry for all samples:
    - Pesticide scan (USGS)
        - All samples
        - Add additional high-risk "indicator" pesticides as practicable[5].
    - Dissolved copper, total suspended solids, dissolved organic carbon, particulate organic carbon
    - Field measurements and general water quality measurements (alkalinity, ammonia, DO, EC, hardness, pH, turbidity etc.) as part of routine toxicity testing
    - Based on need and availability, monitoring data for additional constituents that may influence any observed toxicity would be gleaned from other programs
- ⇨ Pesticide-focused TIEs for samples with ≥ 50% reduction in the organism response compared to the lab control treatment (not to exceed 20% of samples or $40,000)
- ⇨ Frequency: monthly sampling at baseline sites and targeted events-based sampling at additional "targeted" sites
- ⇨ Targeted events (n = 5/year):
    - Wet Weather: (1) First flush, (2) Significant winter storm
    - Dry weather: (1) Late summer irrigation season, (2) Spring runoff, (3) late spring/early summer irrigation season
    - At the baseline sites and for months when targeted wet events occur, targeted wet events sampling will be done in lieu of monthly scheduled sampling

Budget Estimate

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[4] According to: USEPA. 2002a. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. Office of Water, Washington, DC. EPA/821/R-02/012. The SWAMP QAPP specifies Measurement Quality Objectives for this method (http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/mqo/15_acute_toxicity.pdf).

[5] Risk can be evaluated based on DPR's prioritization report (Phase II: http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/prioritization_report_2.pdf), ILRP pesticide evaluation advisory workgroup degradates information.

Component	Water Sampling Low	Medium (Recommended)	Higher-range
Design	"Bare Bones" 5 baseline sites	Hybrid Approach 5 baseline sites plus 3-4 "targeted" sites	High frequency, high intensity 18 baseline sites
Frequency	Baseline sites: monthly	Baseline sites: monthly Targeted-events sites: 5 events	Monthly
Schedule	TBD. The monitoring design will be refined and adaptively managed based on monitoring results, pesticide use reports, and coordination with the ILRP and other programs		
Toxicity	All samples	All samples	All samples
Chemistry	All samples	All samples	All samples
Pesticide-focused TIEs	Up to 20% of samples found ≥50% toxic for at least one endpoint (not to exceed $40,000)	Up to 20% of samples found ≥50% toxic for at least one endpoint (not to exceed $40,000)	Up to 20% of samples found ≥50% toxic for at least one endpoint
Coordination	USGS, IEP-EMP, monthly receiving water monitoring (ILRP, NPDES), SWAMP, stormwater programs	USGS, IEP-EMP, monthly receiving water monitoring (ILRP, NPDES), SWAMP, stormwater programs	USGS, IEP-EMP, monthly receiving water monitoring (ILRP, NPDES), SWAMP, stormwater programs
Annual Cost	$477,000	$627,000	~$1,619,000

Assumptions for estimating costs per site per event:

- Toxicity testing:
  - 3 freshwater test species with a site water vs. a control ($3,125)
  - 96hr survival test with *Hyalella azteca* with a site water vs. a control ($630)
  - Assuming 10% extra for QA lab samples
  - Pesticides-focused TIEs (5 manipulation test including 8 treatments) = $2,700/test up to $40,000 annual limit
- Chemistry tests unit costs:
  - USGS pesticide scan (~$2,060/analysis)[6]
  - Copper analysis ($20)

[6] The full list of target analytes is provided in the Target Parameters subsection.

- TSS analysis ($0 cost, included in pesticide scan)
- Dissolved organic carbon/Particulate organic carbon ($130)
- Assuming 20-30% extra for QA lab samples

Sediment Sampling

The following monitoring conducted by SWAMP Stream Pollution Trends (SPoT) monitoring program will be incorporated into the analysis of current use pesticide effects in the Delta.

- Toxicity testing:
  - *Hyalella azteca* (survival)
  - *Chironomus dilutus/tentans* (survival)
- Chemistry:
  - Pyrethroids
  - Field measurements and general water quality measurements (temperature, DO, EC, pH etc.) as part of routine toxicity testing

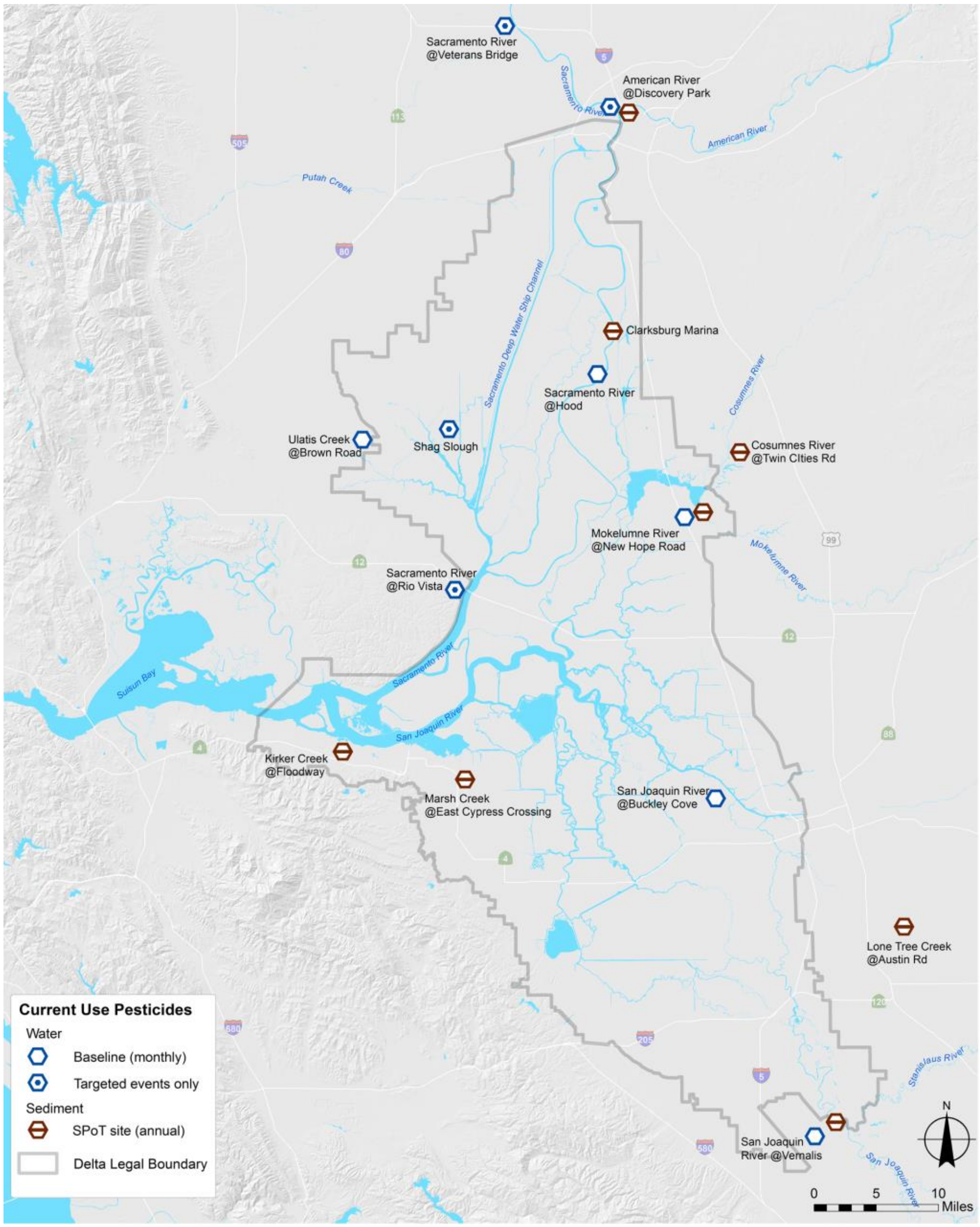
- Events:
  - Late summer

Component	Sediment Sampling Recommended: All in-kind
Design	6 sites
Frequency	1 event
Toxicity	All samples
Chemistry	All samples
Coordination	SPoT does all sampling, toxicity testing, and chemical analyses
Unit Cost	n/a
Annual Cost	No additional investment by Delta RMP

Monitoring Sites

Monitoring sites were selected based on expert opinion considering multiple factors:

- Representative inflows and outflows
- Existing monitoring by others
- Location of Delta RMP core network sites proposed by POTWs
- Existing datasets on which to build
- Spatial distribution



Note: Sediment sampling sites are selected by SPoT at representative sites with sediment deposition. They do not all overlap with water sampling sites.

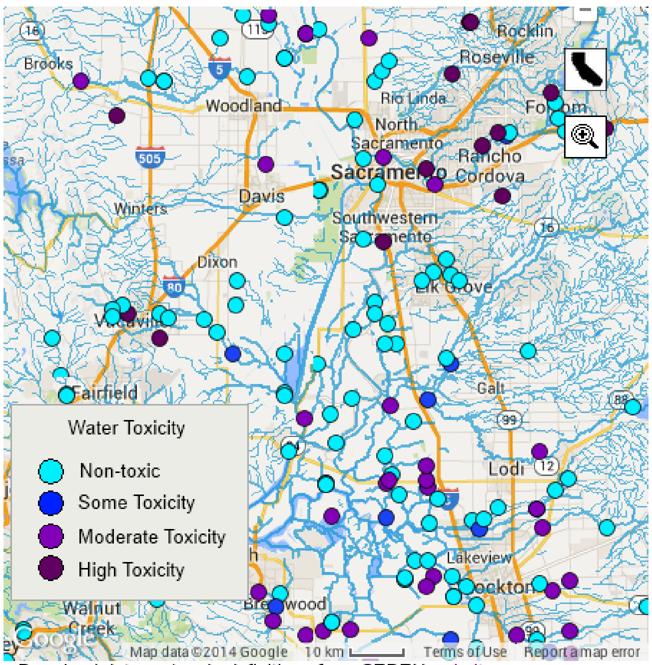
Proposed Sites	Latitude	Longitude	Water - Baseline (monthly)	Water - Targeted Events Only	Sediment (SPoT)* (annual)	Reasons for selection
American River @ Discovery Park	38.60094	-121.5055		X	X	American R watershed. Proposed RMP core site
Marsh C @ E Cypress Crossing (Brentwood)	37.99107	-121.69626			X	Represents Marsh Creek influence (urban and ag/orchards).
Mokelumne R @ New Hope Rd	38.23611	-121.41889	X		X	Tributary influences at eastside boundary, geographic gap.
Sacramento R @ Clarksburg Marina	38.38312	-121.52057			X	SPoT site: in-kind sampling and toxicity testing. Key inflow: Sac R watershed ds of a major wastewater treatment plant/Sac urban area; proposed RMP core site
Sacramento R @ Hood	38.36771	-121.52050	X			Key inflow: Sac R watershed ds of Sac urban area; proposed RMP core site
Sacramento R @ Rio Vista	38.16016	-121.68530		X		Sac River ds of Yolo Bypass, Sac R/DWSC confluence, and in-Delta contributions
Sacramento R @ Veteran's Bridge	38.67460	-121.62817		X		Key inflow: Sac R upstream of Sacramento urban area
San Joaquin R @ Buckley Cove	37.97667	-121.37889	X		X	SJR mainstem ds of Stockton urban area
San Joaquin R @ Vernalis	37.67556	-121.26417	X		X	Key inflow: SJR watershed upstream of Delta boundary. Proposed RMP core site.
Shag Slough @ Liberty Island Bridge	38.30667	-121.69278		X		Ecological significance of Cache/Prospect Slough complex. Ag and urban influences ds of Yolo Bypass. SVWQC site.
Ulatis C @ Brown Ulatis Creek @	38.30667	-121.79472	X			Yolo Bypass site representing

Proposed Sites	Latitude	Longitude	Water - Baseline (monthly)	Water - Targeted Events Only	Sediment (SPoT)* (annual)	Reasons for selection
Brown Rd						Cache/Prospect Slough Complex

*In-kind by State Water Board SWAMP.

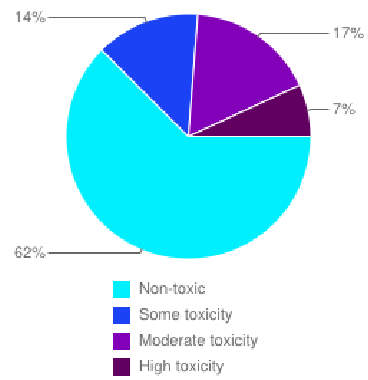
Example Data Products

EXAMPLE: Magnitude of water (sediment) toxicity observed at Delta sampling sites



Download data and code definitions from CEDEN website.

Statewide Statistics - Condition of State's Waters



This map shows data generated by:

SWAMP SFEI

Figure a. Example of a color-coded map of sites (e.g. gradient): cyano = non-toxic blue = some, indigo = moderate, maroon = highly toxic. Annual averages at each site. Categories: Non-toxic = no toxicity detected at site; some toxicity = all samples below high-toxicity threshold; moderate toxicity = mean for all samples less toxic than high-toxicity threshold; high toxicity = mean for all samples more toxic than high-toxicity threshold. High toxicity thresholds specific to each test endpoint are calculated according to Bay et al. (2007).

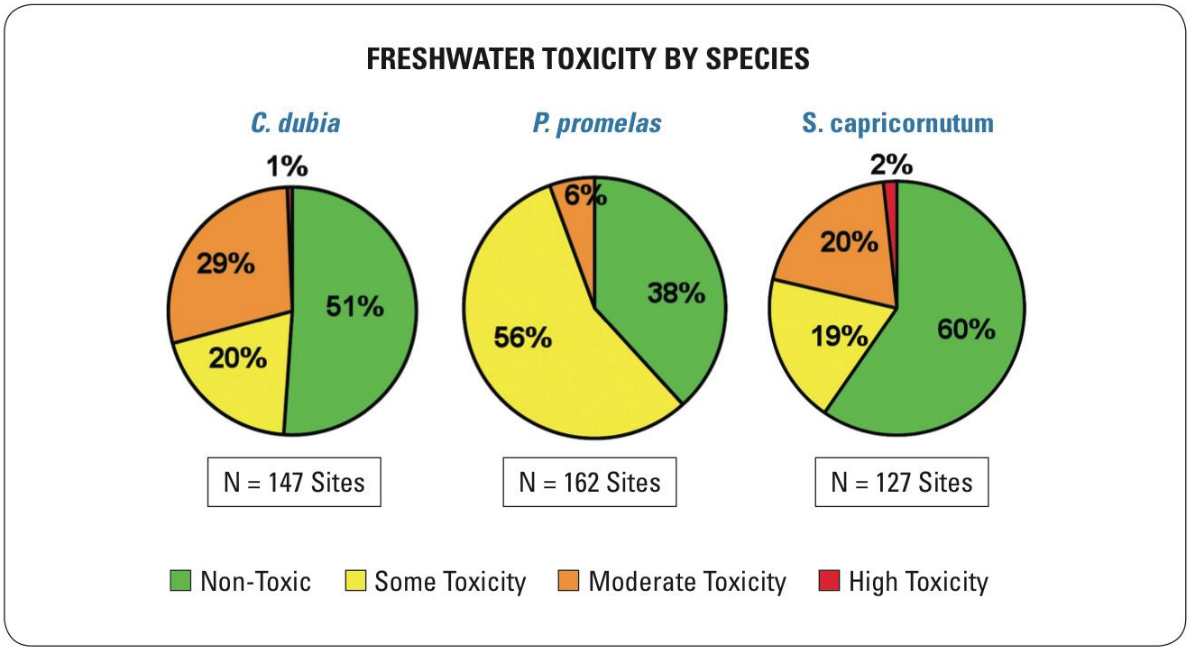


Figure 2. Magnitude of toxicity to individual freshwater species in water samples from the Central Valley Region of California.

Figure b. Example for graphic summary of results for magnitude of toxicity by species/endpoint in water (sediment) samples from the Delta (site x,y,z/flowpath), all data for monitoring year XX.

Toxicity trends (Sampling Year 2+)

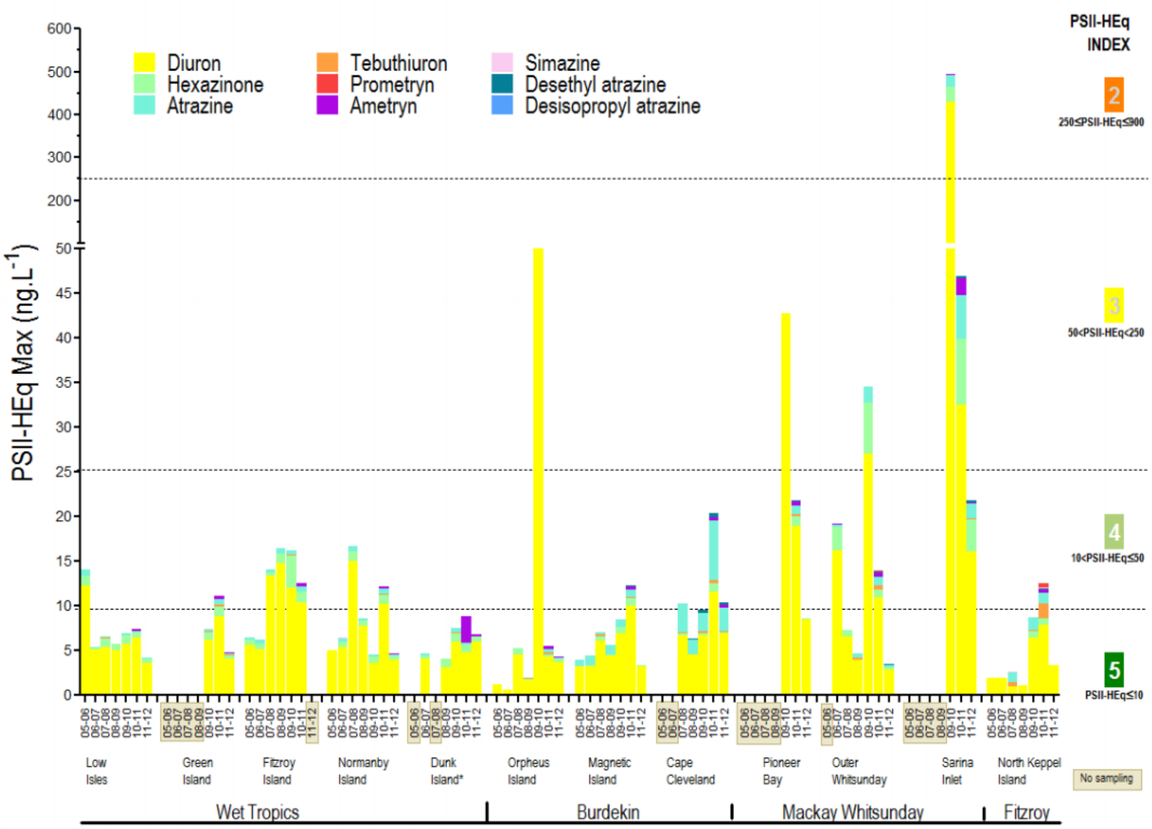
Example: SPoT sediment toxicity trends in tests conducted at 23 °C from 2008-2012 (potentially to provide in graph form).

	2008	**2009**	**2010**	**2011**	**2012**
Number of Sites Tested	92	23	95	100	100
% Non-toxic	83	74	81	85	82
% Toxic	11	17	11	10	9
% Highly Toxic	6	9	8	5	9
% Toxic + % Highly Toxic	17	26	19	15	18

⇨ **Use of toxicity trends results** (in context of chemical-analytical data and other relevant information): Inform success of toxicity reduction efforts over time.

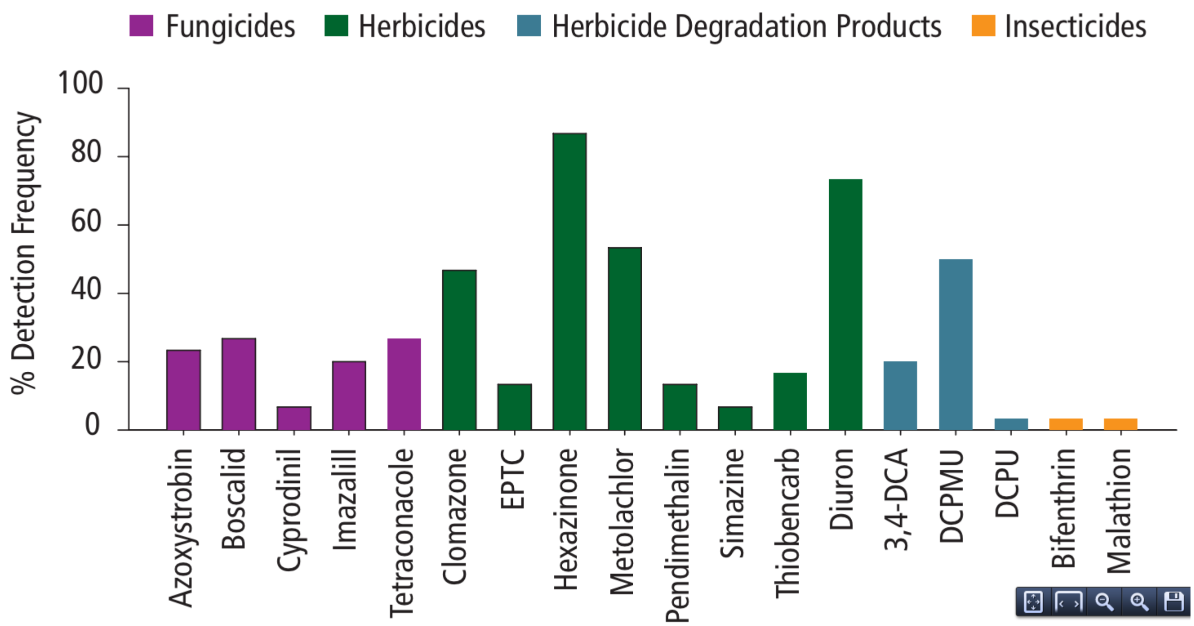
EXAMPLE: Variation in pesticide exposure

Variation in pesticide exposure between sampling events for stations a, b, c,…., grouped by flowpath/watershed/subregion



⇨ **Use of toxicity results and chemical results** (in context of historic data, land uses, pesticide use trends, potentially affected resources, and other relevant information): Identify which indicators should be the focus of monitoring and management.

EXAMPLE: Frequency of pesticide detection



Target Parameters

Current Use Pesticide Sampling – Chemical Analysis Laboratory	
Constituent	**Reporting Group**
Dissolved Organic Carbon (DOC)	Conventional
Particulate Organic Carbon (POC)	Conventional
Total Suspended Solids (TSS)	Conventional
Copper (dissolved)	Metals
Carbaryl	Carbamates
Carbofuran	Carbamates
p,p'-DDD	DDTs
p,p'-DDE	DDTs
p,p'-DDT	DDTs
Desulfinylfipronil	Fipronils
Fipronil	Fipronils
Fipronil sulfide	Fipronils
Fipronil sulfone	Fipronils
(E)-Dimethomorph	Fungicides
Azoxystrobin	Fungicides
Boscalid	Fungicides
Carbendazim	Fungicides
Chlorothalonil	Fungicides

Current Use Pesticide Sampling – Chemical Analysis Laboratory	
Constituent	**Reporting Group**
Cyazofamid	Fungicides
Cymoxanil	Fungicides
Cyproconazole	Fungicides
Cyprodinil	Fungicides
Desthio-Prothioconazole	Fungicides
Difenoconazole	Fungicides
Ethaboxam	Fungicides
Famoxadone	Fungicides
Fenarimol	Fungicides
Fenbuconazole	Fungicides
Fenhexamide	Fungicides
Fluazinam	Fungicides
Fludioxinil	Fungicides
Fluoxastrobin	Fungicides
Flusilazole	Fungicides
Flutriafol	Fungicides
Imazalil	Fungicides
Iprodione	Fungicides
Kresoxim-methyl	Fungicides
Mandipropamide	Fungicides
Metconazole	Fungicides
Myclobutanil	Fungicides
Propiconazole	Fungicides
Pyraclostrobin	Fungicides
Pyrimethanil	Fungicides
Tebuconazole	Fungicides
Tetraconazole	Fungicides
Thiabendazole	Fungicides
Triadimefon	Fungicides
Triadimenol	Fungicides
Trifloxystrobin	Fungicides
Triflumizole	Fungicides
Triticonazole	Fungicides
Zoxamide	Fungicides
3,4-DCA	Herbicides
3,5-DCA	Herbicides
Alachlor	Herbicides
Atrazine	Herbicides
Butylate	Herbicides
Clomazone	Herbicides

Current Use Pesticide Sampling – Chemical Analysis Laboratory	
Constituent	**Reporting Group**
Cycloate	Herbicides
DCPA	Herbicides
DCPMU	Herbicides
DCPU	Herbicides
Diuron	Herbicides
EPTC	Herbicides
Ethalfluralin	Herbicides
Fluridone	Herbicides
Hexazinone	Herbicides
Metolachlor	Herbicides
Molinate	Herbicides
Napropamide	Herbicides
Oryzalin	Herbicides
Oxyfluorfen	Herbicides
Pebulate	Herbicides
Pendimethalin	Herbicides
Penoxsulam	Herbicides
Prometon	Herbicides
Prometryn	Herbicides
Propanil	Herbicides
Propyzamide	Herbicides
Simazine	Herbicides
Thiobencarb	Herbicides
Trifluralin	Herbicides
Chlorantraniliprole	Insecticides
Cyantraniliprole	Insecticides
Flonicamid	Insecticides
Methoprene	Insecticides
Methoxyfenozide	Insecticides
Tolfenpyrad	Insecticides
Acetamiprid	Neonicotinoids
Clothianidin	Neonicotinoids
Dinotefuran	Neonicotinoids
Imidacloprid	Neonicotinoids
Thiacloprid	Neonicotinoids
Thiamethoxam	Neonicotinoids
Pentachloroanisole (PCA)	Organochlorines
Pentachloronitrobenzene (PCNB)	Organochlorines
Chlorpyrifos	Organophosphates
Diazinon	Organophosphates
Malathion	Organophosphates

Current Use Pesticide Sampling – Chemical Analysis Laboratory	
Constituent	**Reporting Group**
Methidathion	Organophosphates
Methylparathion	Organophosphates
Phosmet	Organophosphates
Allethrin	Pyrethroids
Bifenthrin	Pyrethroids
Cyfluthrin	Pyrethroids
Cyhalothrin	Pyrethroids
Cypermethrin	Pyrethroids
Deltamethrin	Pyrethroids
Esfenvalerate	Pyrethroids
Etofenprox	Pyrethroids
Fenpropathrin	Pyrethroids
Permethrin	Pyrethroids
Phenothrin	Pyrethroids
Resmethrin	Pyrethroids
t-Fluvalinate	Pyrethroids
Tefluthrin	Pyrethroids
Tetramethrin	Pyrethroids
Piperonyl butoxide	Synergists

Current Use Pesticide Sampling – Toxicity Testing Laboratory Analysis	
Constituent	**Reporting Group**
Alkalinity as $CaCO_3$	Conventional
Ammonium as N	Conventional
Electrical Conductivity	Conventional
Hardness as $CaCO_3$	Conventional
Oxygen, Dissolved	Conventional
pH	Conventional
Specific Conductivity	Conventional
Temperature	Conventional
Ceriodaphnia dubia (Reproduction)	Water Column Toxicity
Ceriodaphnia dubia (Survival)	Water Column Toxicity
Hyalella azteca (Survival)	Water Column Toxicity
Onchorynchus mykiss (Larval survival)	Water Column Toxicity
Pimephales promelas (Larval biomass)	Water Column Toxicity

Pimephales promelas (Larval survival)	Water Column Toxicity
Selenastrum capricornutum (Growth)	Water Column Toxicity

Current Use Pesticides Sampling	
Constituent	**Reporting Group**
Oxygen, Dissolved	Field Parameters
Oxygen, Dissolved	Field Parameters
pH	Field Parameters
Specific Conductivity	Field Parameters
Temperature	Field Parameters
Turbidity	Field Parameters

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Mercury

Specific Monitoring Design Details

DELTA RMP
Regional Monitoring Program

Technical Advisory Committee

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Specific Monitoring Design Details – Mercury

Initial Assessment Questions

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

A. Are trends over time in methylmercury in **sport fish** similar or different among Delta subareas?

B. Are trends over time in methylmercury in **water** similar or different among Delta subareas?

The monitoring design focuses on the two bolded elements.

Study Design

Fish Sampling

- ⇨ Indicator of primary interest is methylmercury in muscle fillet of 350-mm largemouth bass (or similar predator species). Methylmercury in muscle fillets of other TL3 and TL4 species are indicators of secondary interest.
- ⇨ Budget estimates do not include data management, QA, and reporting.

Funding Level	**Lower - Recommended**	**Higher**
Design	10 fixed sites, bass only	10 fixed sites and 10 random draw, bass only
Frequency	Annual	Annual
Schedule	Continue for 10 years but evaluate annually. Sample in summer or early fall.	Continue for 10 years but evaluate annually. Sample in summer or early fall.
Co-location	– Water Hg (selected sites) – Other water parameters (selected sites)	– Water Hg (selected fixed sites only) – Other water parameters (selected fixed sites)
Coordination	None	None
Unit Cost:	$7,300/site-yr ($7000 per year bass only; include other TL4 and TL3 species once every 5 years @$8500 per site)	$7,000/site-yr
Annual Cost	$73,000	$140,000

Water Sampling

- ⇨ Indicator of primary interest is total methylmercury in water (measured as sum of particulate and dissolved).
- ⇨ Important ancillary parameters include particulate and dissolved total Hg, nutrients, chlorophyll, DOC/POC, grain size, suspended sediment, POC. Budget assumes nutrients covered by other funds; other parameters covered by budget in table below.
- ⇨ Budget estimates do not include data management, QA, and reporting.

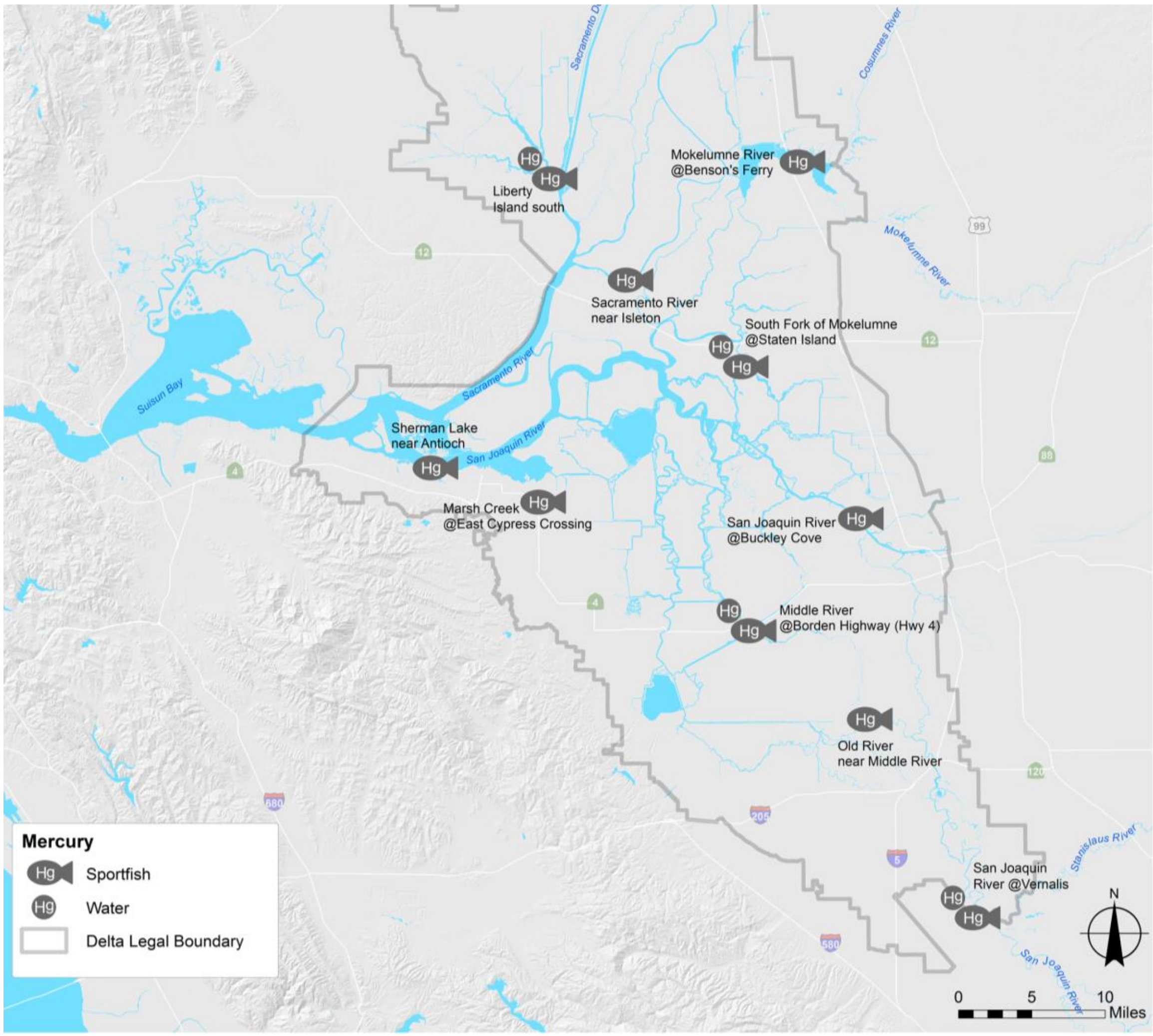
Funding Level	**Lower**	**Mid-range - Recommended**	**Higher**
Design	5 fixed sites	5 fixed sites	5 fixed sites
Frequency	Monthly	10 months/year*	Monthly
Schedule	Continue for 5 years and then re-evaluate	Continue for 5 years but evaluate annually	Continue for 5 years but evaluate annually
Co-location	– Sport fish sampling – Other water parameters	– Sport fish sampling – Other water parameters	– Sport fish sampling – Other water parameters
Coordination	**Assumes sampling provided in-kind**	None - Sampling conducted by DRMP	None - Sampling conducted by DRMP
Unit Cost:	$1150/site-month; $5,750/month for the 5 sites	$2750/site-month; $13,750/month for the 5 sites	$2750/site-month; $13,750/month for the 5 sites
Annual Cost	$69,000	$138,000	$165,000

* Samples could be distributed farther apart in time than monthly during summer-fall when conditions change less and less rapidly.

Monitoring Sites

Monitoring sites were selected based on expert opinion considering multiple factors:

- Existing long-term datasets on which to build
- Spatial distribution, especially relative to Delta Hg TMDL subareas
- Representative inflows and outflows
- Proximity to major wetland restoration areas
- Existing monitoring by others, particularly USGS and discharge permittees
- Accessibility and popularity (such as for fishing)



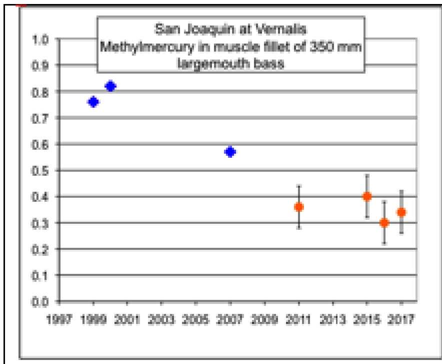
Proposed Sites	**Latitude**	**Longitude**	**Sport Fish (annual)**	**Water (monthly)**	**Reasons for selection**
Sacramento R nr Isleton	38.163	-121.61	(X)		TMDL linkage site, Sacramento River (TMDL Subarea 3)
Mokelumne R ds Cosumnes R	38.25528	-121.44	X		TMDL linkage site, long-term time series, Mokelumne/Cosumnes River (TMDL Subarea 4)
MID flux station	37.89083	-121.48833	X	X	TMDL linkage site, long-term time series, Central Delta (TMDL Subarea 5), permittee-proposed RMP site, priority site for model input, co-location (fish/water)
Old R nr Middle River	37.821	-121.371	(X)		Permittee-proposed RMP site, San Joaquin River (TMDL Subarea 6)
San Joaquin R @ Vernalis	37.67556	-121.26417	X	X	TMDL linkage site, long-term time series, San Joaquin River (TMDL Subarea 6), priority site for model input, piggyback opportunity, co-location (fish/water)
Sherman Lake	38.0177	-121.80273	X		TMDL linkage site, West Delta (TMDL Subarea 7)
Marsh Creek	37.99107	-121.69626	(X)		TMDL linkage site, Marsh Creek (TMDL Subarea 8)
Little Potato Slough	38.09627	-121.49601	X	X	Permittee-proposed RMP site, Marsh Cr long-term time series, priority site for model input
Liberty Island	38.2421	-121.6849	X	X	Priority site for model input

(x) = tentative

Example Data Products

These data products will connect directly to assessment questions S&T 1 A and B by comparing trends among sites.

Methylmercury in Sport Fish



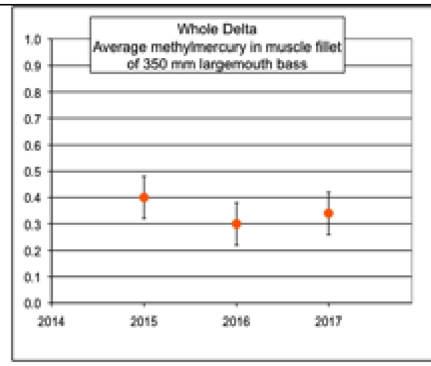
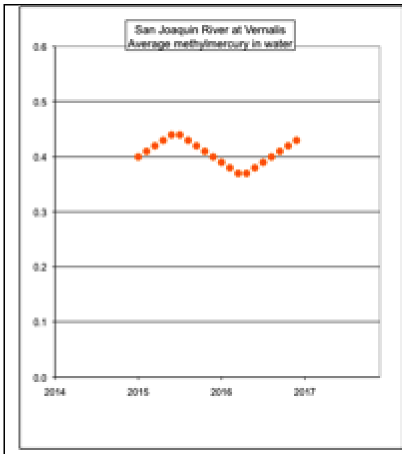


Figure 1. Annual average tissue THg concentrations for largemouth bass at the San Joaquin River at Vernalis. Historical data shown in blue; Delta RMP data shown in orange. Diamonds represent averages based on ANCOVA-generated estimates for a standard size of 350 mm[7]. Error bars represent 95% confidence intervals of the mean. Red line [not shown in these examples] indicates 0.24 ppm water quality objective for trophic level 4 fish.

Figure 2. Annual average tissue THg concentrations for largemouth bass in the Delta. Diamonds represent averages across stations based on ANCOVA-generated estimates for a standard size of 350 mm. Error bars represent 95% confidence intervals of the mean. Red line indicates 0.24 ppm water quality objective for trophic level 4 fish.

[7] This size was initially selected in the CALFED Mercury Project in 2000. It is in the middle of the size range of largemouth that are commonly and legally caught.

Water Sampling



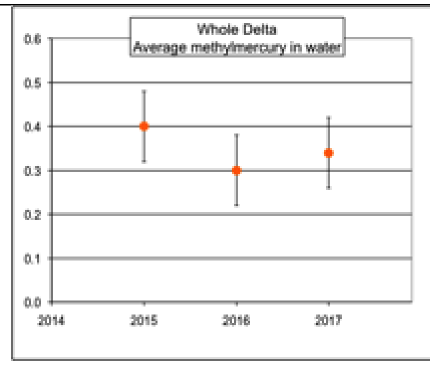


Figure 3. Unfiltered methylmercury concentrations in water at the San Joaquin River at Vernalis. Diamonds represent monthly observations. Red line indicates 0.06 ng/L implementation goal for the TMDL.

Figure 4. Annual average unfiltered methylmercury concentrations in water in the Delta. Diamonds represent monthly observations. Error bars indicate 95% confidence interval for the mean. Red line indicates 0.06 ng/L implementation goal for the TMDL.

Target Parameters

Sport Fish Sampling		
Constituent/Measurement	**Reporting Group**	**Matrix**
Mercury	Metals	Tissue (fillet muscle)
Total Length (mm)	Fish Attributes	Tissue
Fork Length (mm)	Fish Attributes	Tissue
Weight (g)	Fish Attributes	Tissue
Sex	Fish Attributes	Tissue
Moisture (%)	Fish Attributes	Tissue

Water Sampling		
Constituent/Measurement	**Reporting Group**	**Matrix**
Methylmercury (particulate)	Metals	Water
Methylmercury (dissolved)	Metals	Water

Water Sampling		
Constituent/Measurement	**Reporting Group**	**Matrix**
Mercury (dissolved)	Metals	Water
Mercury (particulate)	Metals	Water
Ammonium as N	Conventional	Water
Chlorophyll a	Conventional	Water
Dissolved Organic Carbon	Conventional	Water
Grain Size	Conventional	Water
Hardness as $CaCO_3$	Conventional	Water
Nitrate as N	Conventional	Water
Nitrite as N	Conventional	Water
Nitrogen, total	Conventional	Water
Particulate Organic Carbon	Conventional	Water
Orthophosphate as P	Conventional	Water
Phosphorus, total	Conventional	Water
Silica as SiO2	Conventional	Water
Sulfate	Conventional	Water
Suspended Sediment Concentration	Conventional	Water
Total Dissolved Solids	Conventional	Water
Total Organic Carbon	Conventional	Water

Nutrients

Specific Monitoring Design Details

DELTA RMP
Regional Monitoring Program

Technical Advisory Committee

AQUATIC SCIENCE CENTER

Monitoring Design Summary – Nutrients

Initial Assessment Questions

S&T 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. Are there important data gaps associated with particular water bodies within the Delta subregions?

SPLP 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?

Study Design

The recommended approach for nutrients is to support and build upon other ongoing activities, which will provide a comprehensive knowledge base for nutrients in the Delta. Initial efforts focus on a) synthesis and analysis of existing information and data and b) development of the Delta RMP nutrient monitoring design. The planned data synthesis activities will serve to:

1. Improve our understanding of the spatial and temporal distribution of nutrients and nutrients-associated parameters in the system, and
2. Glean monitoring development needs.

The following steps will be undertaken to develop a monitoring plan for nutrients. Synthesis and a coordination tasks will occur first. The detailed monitoring design will be built off these initial steps.

1. **Synthesize and analyze existing information and data**.
    a. Synthesize and analyze existing data
    b. Establish meaningful subregions and subregion-habitat combinations

   c. Identify critical data gaps and develop initial recommendations for monitoring design

2. **Coordinate with development of the Delta Nutrient Research Plan and other SFEI-ASC Delta nutrients work.**
   a. Review and evaluation of results from initial Nutrient Research Plan white papers
   b. Coordinate next steps

3. **Develop nutrient monitoring design.**
   c. Define sampling frame (habitats, subareas)
   d. Data evaluation and reconciliation
   e. Complete and vet a detailed monitoring and design proposal for nutrients
   f. Develop mechanisms for systematically compiling, assessing, and reporting data

The goal is to produce a Delta RMP nutrient monitoring and assessment plan by June 2016, but the pace of this work is dependent on funding.

The following table shows the approximate costs for steps to develop the nutrient monitoring design. For projects that already have funding from outside the Delta RMP, the cost of the project is shown but is offset by the available outside funding. This table does not include the costs of routine nutrient monitoring. Costs for a longer-term nutrient monitoring will be developed after the monitoring design has been produced.

Task	Cost	Available Funding from non-RMP sources	Shortfall (RMP funding needed)
1. Synthesis and analysis of existing information and data			
a. Synthesize and analyze existing data			
Synthesis of EMP and Nutrient Loads data (ASC-DWR contract)	$82,000	$82,000	$0
Interpretation of stable isotope data (ASC-DWR contract)	$34,000	$34,000	$0
Calibration and interpretation of DSM2 nutrient models (ASC-DWR contract)	$39,000	$39,000	$0
Synthesis of high-frequency sensor data	$70,000	$0	$70,000
Compilation and synthesis of other nutrient datasets from the Delta	$40,000	$0	$40,000

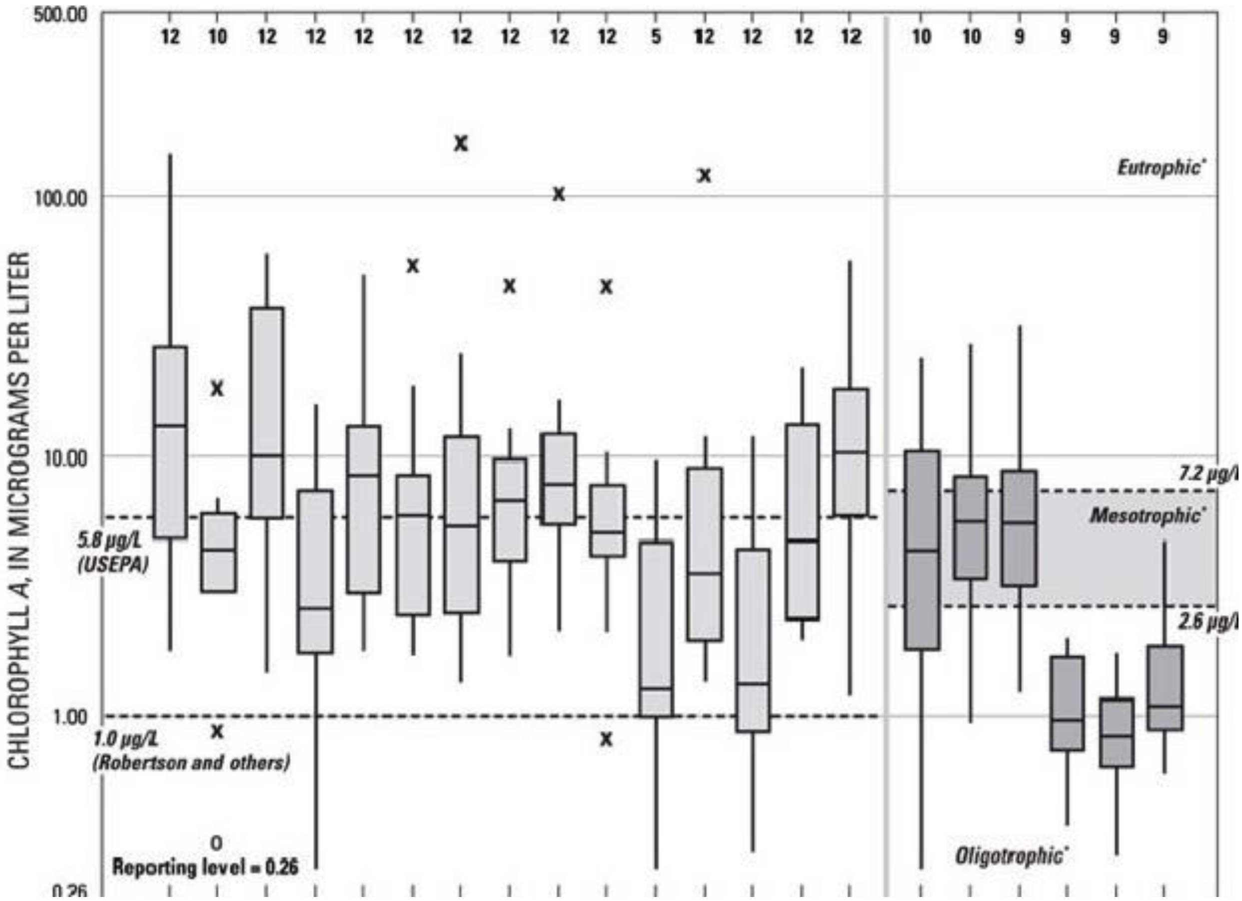
b. Establish meaningful subregions			
Synthesis of Nutrient Data and Analyses to Determine Delta Segments for Nutrient Assessments and Modeling (ASC-DSP contract)	$40,000	$40,000	$0
c. Identify critical data gaps and develop initial recommendations for monitoring design	$50,000	$0	$50,000
2. Coordination			
a. Coordination with the development of the Delta Nutrient Research Plan and related efforts (ASC-DSP contract)	$15,000	$15,000	$0
3. Develop nutrient monitoring design			
a. Define sampling frame (habitats, subareas) b. Data evaluation and reconciliation c. Complete and vet a detailed monitoring and design proposal for nutrients d. Develop mechanisms for systematically compiling, assessing, and reporting data	$65,000	$0	$65,000
Total amount	***$435,000***	***$210,000***	***$225,000***

Example Data Products

Examples for Data Analysis Products.

1. ***Ranges in concentrations in Delta subareas in concentrations of nutrients and nutrient-associated parameters***

EXAMPLE 1: Ranges in chl-a concentrations

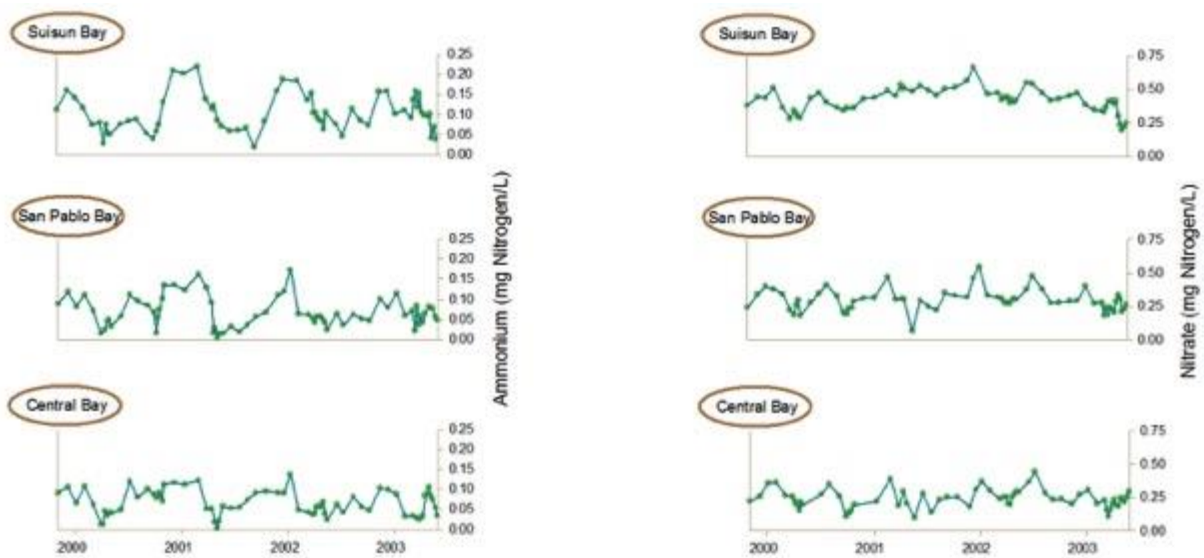


Representation: Box-and-whisker-plots; x axis can be station groups organized by subregion, habitat type, or subregion*habitat type. Shown here: the distribution of total nitrogen concentrations, by site, in the Milwaukee Metropolitan Sewerage District planning area, Wis. From Thomson et al., 2007).

2. ***Temporal variability in concentrations of nutrients across subregions and habitat types***

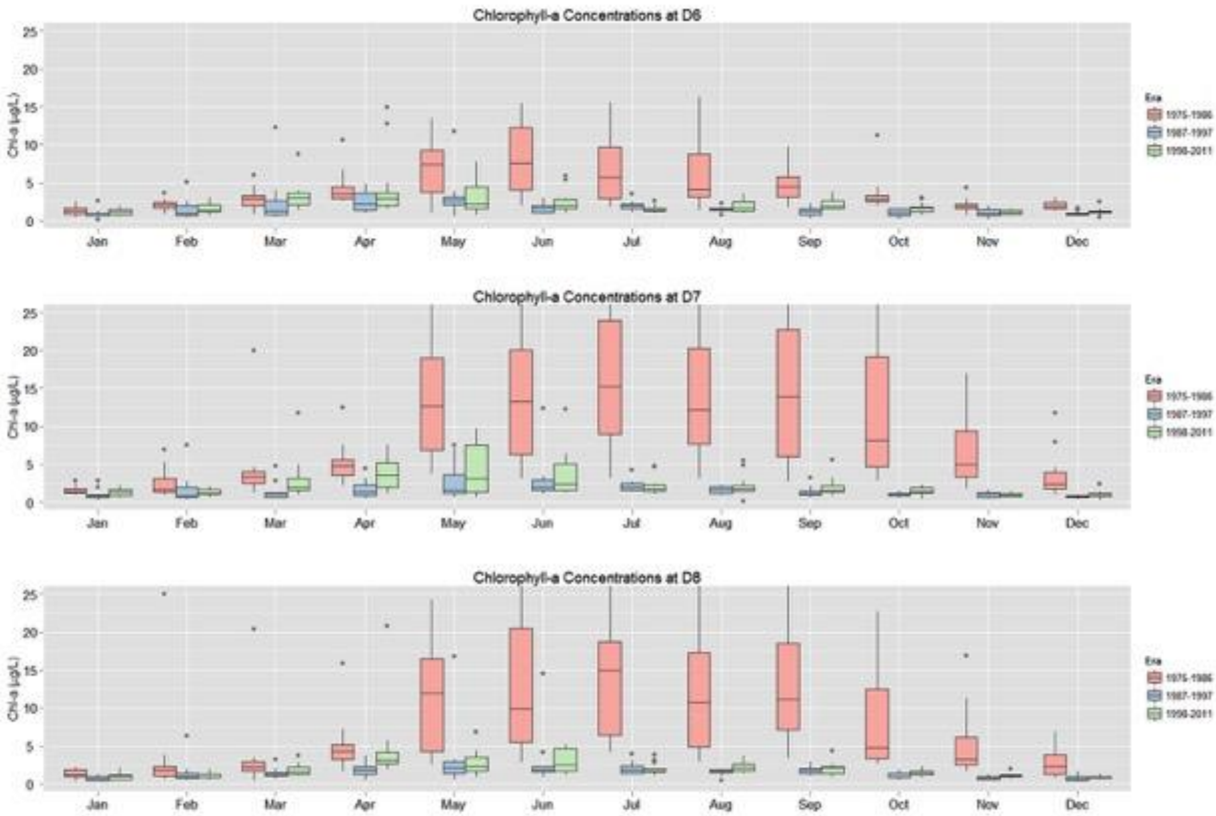
EXAMPLE 2: Seasonal trends in ammonium and nitrate concentrations subregions

Shown here: monthly measurements of ammonium and nitrate in embayments (subregions) of the Northern San Francisco Estuary. From Pulse of the Delta 2011 (ASC), data adapted from Dugdale et al. (2007).



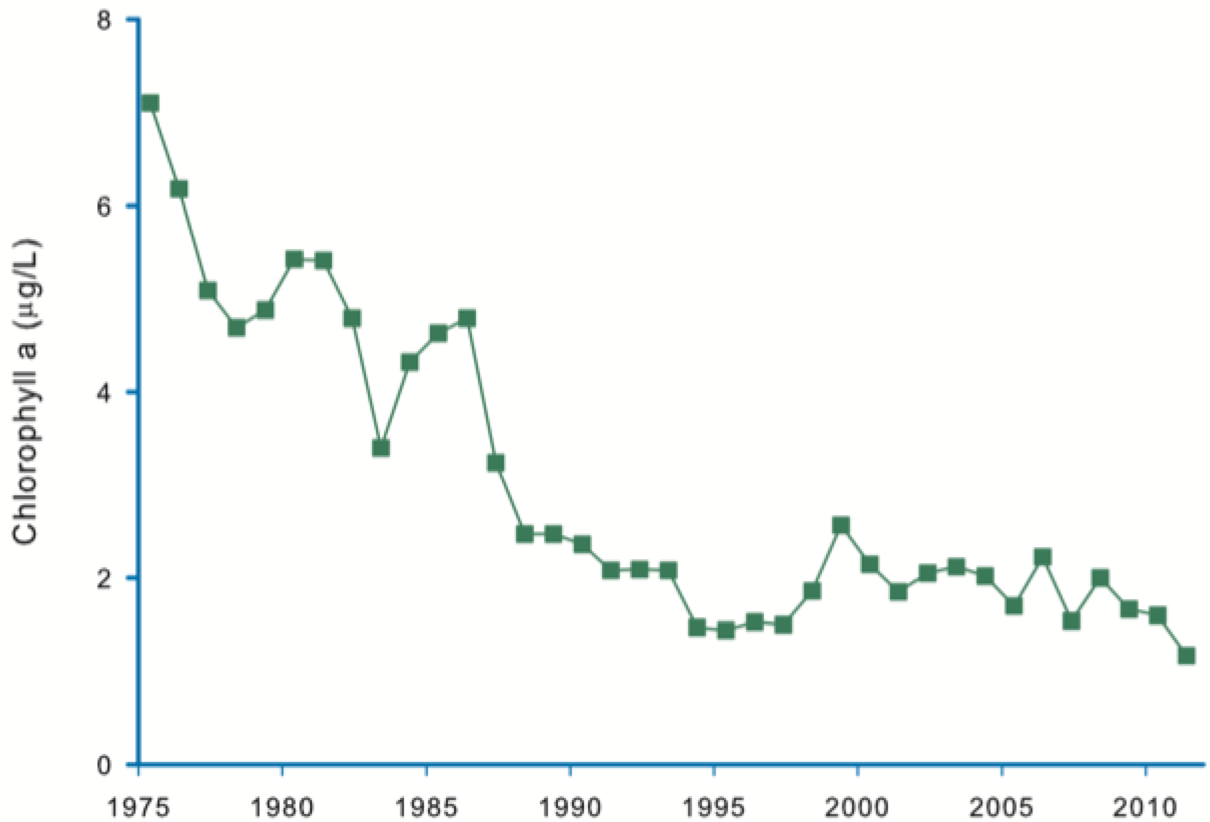
3. *Seasonal, interannual, and decadal variability in concentrations of chl-a and DO across subregions and habitat types*

EXAMPLE 3.1: Seasonal and decadal variations in chl-a concentrations



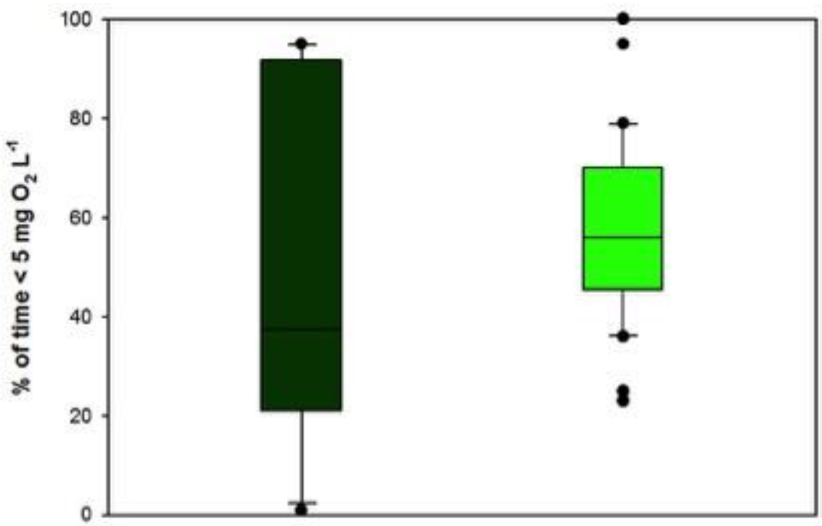
Representation: Box-and-whisker-plots; x-axis are months. Different colors represent different eras (1975-86, 1987-1997, 1998-2011). Shown here: monthly and decadal trends in chl-a concentrations at three Delta stations sampled by the IEP discrete water quality sampling program (DWR-EMP). (For the envisioned product, these plots would be made for subregions and habitat types instead of individual stations).

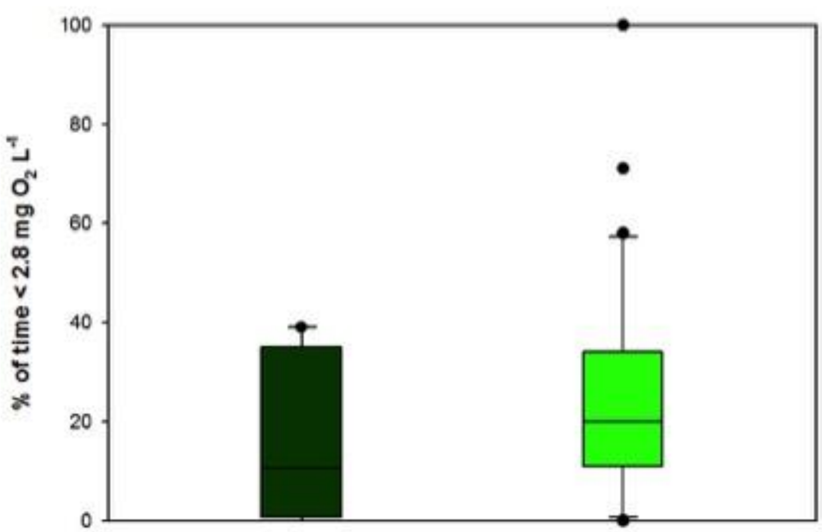
EXAMPLE 3.2: Interannual variation in chl-a concentrations



Shown here: Chl trends in Delta (annual Delta-wide averages), based on IEP discrete water quality data 1975-2011 (DWR-EMP).

EXAMPLE 3.3: Ranges in DO concentrations

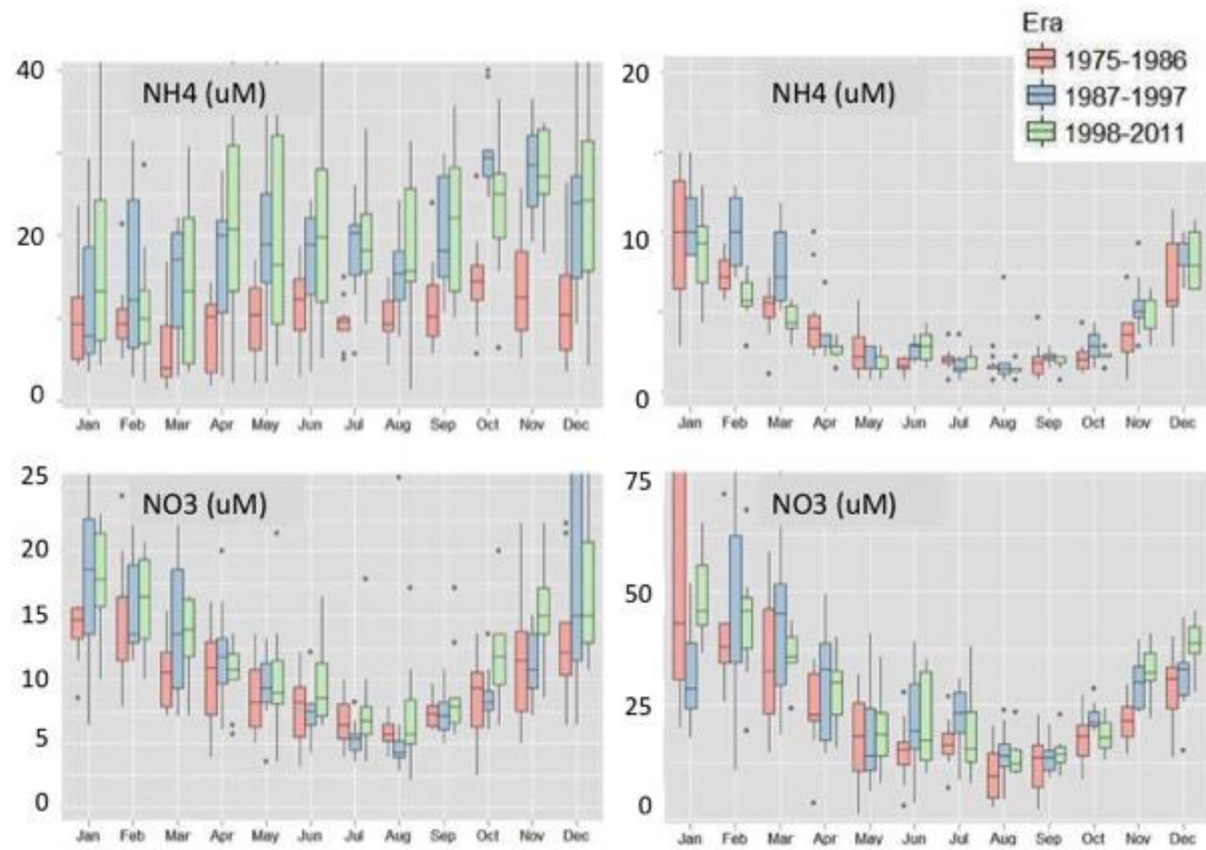




Representation: Frequency of exceedance (%) vs. habitat type (box plots)[or subregion or subregion*habitat type]. Shown here: Frequency of exceedance (%) vs. habitat type (box plots) in South San Francisco Bay. For calculating the mean (horizontal line inside each box), each station's frequency was considered as an individual value. Upper and lower edges of boxes are the upper and lower quartiles, and error bars represent ± 1 standard deviation. The value of 5 mg O2 L-1 is equivalent to the San Francisco Bay Basin Plan objectives for tidal waters downstream of the Carquinez Bridge (SFRWQCB 2013) and values below are generally considered to be oxic but low quality waters (Vaquer-Sunyer and Duarte 2008, Sutula et al. 2012). Waters with DO concentrations < 2.8 mg O2 L-1 are considered hypoxic and acutely toxic to fish (Sutula et al. 2012). The examples are from a synthesis of existing DO data in South SF Bay (Jabusch et al. 2013).

4. *Spatial, seasonal, and temporal trends in nutrient concentrations and proportions*

EXAMPLE 4: Seasonal and decadal variations in NH4 and NO3 concentrations



Representation: Box-and-whisker-plots; x-axis are months. Different colors represent different eras (1975-86, 1987-1997, 1998-2011). Shown here: monthly and decadal trends in ammonium and nitrate concentrations at two Delta stations sampled by the IEP discrete water quality sampling program (DWR-EMP). (For the envisioned product, these plots would be made for subregions and habitat types instead of individual stations).

Target Parameters

The nutrient data synthesis will focus on the following parameters		
Constituent/Measurement	**Reporting Group**	**Matrix**
Ammonium	Conventional	Water
Chlorophyll a	Conventional	Water
Dissolved oxygen	Conventional	Water
Nitrate	Conventional	Water
Dissolved inorganic nitrogen (DIN)	Conventional	Water
Total dissolved nitrogen (TDN)	Conventional	Water
Dissolved organic nitrogen (DON)	Conventional	Water
Phosphate	Conventional	Water

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Pathogens

Specific Monitoring Design Details

DELTA RMP
Regional Monitoring Program

Technical Advisory Committee

AQUATIC SCIENCE CENTER

Specific Monitoring Design Details – Pathogen Study

Initial Assessment Questions

ST1 Are current pathogen levels supportive of the municipal drinking water quality beneficial use as described in the Basin Plan?

A. Are the current pathogen levels for each Delta water intake and those immediately upstream (i.e., Sacramento Area) different than the previous LT2 sampling? Are any drinking water intakes reclassified into a higher bin level?

B. Are Basin Plan trigger values exceeded?

SPLP1 Can any changes in bin level be attributed to an identifiable event, condition, or changes in a source?

A. What are the concentrations in ambient waters upstream or downstream from intakes with observed changes to bin levels?

B. What is the influence of sources (agriculture, POTWs, urban runoff, upstream tributary, natural, recreation, and other) on pathogen levels at drinking water intakes?

C. Are there new discharges or changes in sources or conditions that could explain the change in bin level compared to previous LT2 monitoring?

Study Design

The Central Valley Regional Water Quality Control Board (Central Valley Water Board) adopted a Basin Plan Amendment to establish a Drinking Water Policy (Policy) to protect source water quality on July 26, 2013. The Policy includes a narrative water quality objective for two pathogens, *Cryptosporidium* and *Giardia*, with associated implementation and monitoring provisions, as well as language addressing other constituents of potential concern to drinking water. The proposed Pathogen Study is intended to satisfy the data needs and monitoring for any follow-up required if Basin Plan trigger values are exceeded.

The Pathogen Study will be performed over two or more years. The first two years include ambient characterization monitoring coordinated through the Delta RMP, concurrent with water intake monitoring performed by drinking water agencies. Based on an assessment of data collected in the first year of the characterization study, a Delta subarea could be targeted for special studies of infectability, source tracking, hydrodynamics, and decay and growth.

WATER INTAKE AND AMBIENT SAMPLING (APRIL 2015 – MARCH 2017)

The Pathogen Study will focus on characterizing pathogen (*Cryptosporidium* and *Giardia*) levels to address the objectives of the Pathogen Special Study required by the Central Valley Drinking Water Policy Basin Plan Amendment. The study includes monitoring at the drinking water intake locations and at ambient locations throughout the Delta.

Water Intake Sampling

As part of the second round of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2), water supply agencies are required to collect *Cryptosporidium* and *Giardia* samples monthly for two years in the source waters at treatment plant intakes[8] starting in April 2015. These data will be used to determine if the bin levels[9] assigned after the first round of monitoring are still valid or need to be revised. The second round of monitoring will also be used to evaluate conditions relative to the Basin Plan trigger levels (80% of bin level). For this intake monitoring, there is no direct sampling cost to the Delta RMP, and therefore no range of activity and costs. Indirect costs to the Delta RMP could be incurred to work with the CVDWPWG to coordinate, compile, and review the first year of data for the assessment. Water intake sampling will address the question ST1 (see above)

Design	***7 drinking water intake sites, each with a single source, and 2 facilities with blending from 4 drinking water intakes.***
Frequency	Monthly
Schedule	April 2015-March 2017
Co-location	All LT2 sampling sites, constituent list TBD
Coordination	Water agencies will collect and analyze samples; CVDWPWG and Delta RMP will coordinate, compile, and review the first year of data for the assessment
Unit Cost	$0 per site for sample collection and analysis
Annual Cost	Coordination with water agencies provided as in-kind service; cost is not estimated.

Ambient Sampling

Ambient sampling results, when analyzed in coordination with the intake sampling results, will address the question SPLP 1 above. The mid-range sample collection frequency shown below is the preferred approach as it matches the frequency of the expected LT2 water intake sample collection, and there is no significant benefit to an increased sample collection frequency.

Funding Level	***Lower***	***Mid-range***	***Higher***
Design		12 fixed ambient Delta sites co-located with MWQI locations	

[8] LT2 Source Water Monitoring Guidance specifies that "LT2 Rule monitoring is intended to assess the mean Cryptosporidium level in the influent to drinking water plants that treat surface water or ground water under the direct influence (GWUDI) of surface water. PWSs are required to collect source water samples for the LT2 Rule from each plant intake prior to chemical treatment" http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_swmonitoringguidance.pdf

[9] http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/fs_sw_monitoring_fs_sch_1-3_final.pdf

Frequency	Every other month	Monthly	Twice Monthly
Schedule		Currently planned as a two-year study	
Co-location	.	MWQI program constituent list (varies by program, but typically includes Std. mineral and nutrients, TOC, DOC, UVA, suspended solids and/or turbidity)	
Coordination		Assumes sampling provided in-kind by MWQI and coordination with MWQI provided as in-kind service	
Unit Sample Cost:		$500 per sample, adjusted for QC samples	
Annual Cost	$36,000	$72,000	$144,000

YEAR 2 (APRIL 2016 – MARCH 2017) SPECIAL STUDY MONITORING

During the second year of the Pathogen Study, the same level-of-effort will continue for water intake and ambient characterization, with the addition of special studies. The special studies will be selected based on an analysis of the data collected during Year 1. During the end of Year 1, the Delta RMP will design Year 2 monitoring to address the additional assessment questions, depending on the available funds, and additional time may be necessary to completely address the assessment questions

Data Assessment to Determine Year 2 Special Study Monitoring

After 8-12 months of data are available from the Year 1 study, the drinking water intake data will be evaluated to determine likely trigger exceedances at drinking water intakes. The Drinking Water Policy Basin Plan amendment defines the trigger as the *Cryptosporidium* concentration reaching 80% of the next highest bin level. This assessment process will also evaluate the ambient concentrations of *Cryptosporidium* near to the intakes where any bin changes were identified. If no bin changes are observed or expected, a Year 2 special study would be performed in the Sacramento area because this area has the highest density of water intakes, in the previous LT2 sampling one intake in the area was close to the Basin Plan trigger, and the influences from different sources can be better discerned.

Year 2 Special Study Design

The Year 2 study will be designed following the process shown in the flowchart shown below. Year 2 monitoring may include the following tools and studies to address the Year 2 assessment questions:

Infectivity monitoring – *Cryptosporidium* infectivity can be assessed by a cell culture method known as the *Cryptosporidium* sporozoites infectivity assay (Cell Cultures-IFA-Based Foci

Detection). However, there is not an analogous method currently available for *Giardia,* as host infection methods can be expensive and rely on infecting mammals.

Infectivity monitoring is dependent on sufficient detection of *Cryptosporidium*. If a site is identified with consistent detection of *Cryptosporidium*, an infectivity assessment could potentially provide information about whether *Cryptosporidium* oocysts are capable of causing an infection in humans. If there are no ambient sites with sufficient detection, infectivity monitoring could be conducted at source locations (e.g., wastewater treatment plant effluent).

Infectivity monitoring could be used to evaluate whether there are infectivity rate differences between *Cryptosporidium* in ambient waters and sources, provided that there is sufficient detection in ambient waters.

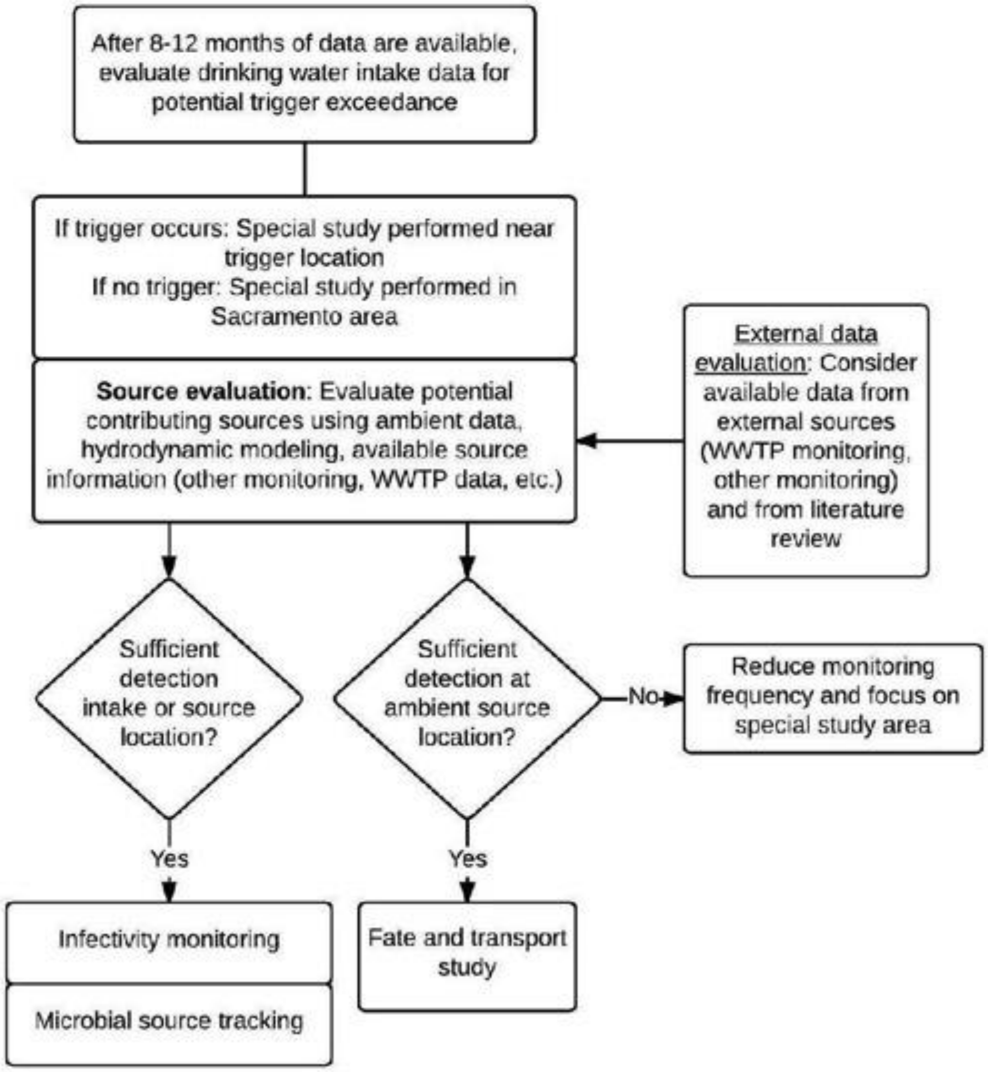
Microbial source tracking (MST) - MST utilizing polymerase chain reaction (PCR) techniques examines specific nucleic acid sequences from intestinal bacteria (*Bacteroidales*) that can provide detail on the origin of the microbes and associated pathogenic organisms. This technique can provide additional information to evaluate the influence of sources at drinking water intakes.

These analyses would be performed as follow-up to a likely trigger exceedance. Analyzing ambient samples in the vicinity of intakes with a likely trigger exceedance can provide information on the relative host contributions (e.g., gull, cow/horse, dog, human sources) to bacteria populations at the ambient locations of interest. That information could help in deciding what sources should be investigated as potential contributors (e.g., agriculture if bacteria from cow/horse are a high percentage of total bacteria).

Hydrodynamics – The relative contribution of upstream sources (tributaries) to a water intake would be examined using available fingerprinting outputs from observed and modeled conditions. This evaluation may be performed in Year 1 if likely bin level changes are observed. Fingerprinting would be developed on monthly basis by DWR, and source volumetric contributions would be developed through existing data (DWR, USGS, and other gages) and estimates developed by others (stormwater, agriculture, other). A summary would be developed of the monthly fingerprinting and estimates of the relative volumetric comparison from sources to the location of the bin level change. This information would help determine if an upstream source, given its volumetric contribution, could potentially have contributed a sufficient concentration of pathogens to be a factor in a bin level change.

Fate and transport – The fate and transport of protozoan pathogens in the Delta could be examined through a literature evaluation, and potentially through an in-situ evaluation. A literature review and summary would first be necessary, and could be performed during Year 1. Information on decay rates and environmental processes could be used to inform modeling efforts.

If *Cryptosporidium* and *Giardia* are detected at high concentrations in ambient locations, an in-situ study could be performed to follow a pulse of ambient water through the watershed to observe changes in *Cryptosporidium* and *Giardia* concentrations. This study would be costly, and would rely on consistent detection of the protozoa in the ambient water.



Potential Source Locations:

- Agriculture: MWQI #14, #1
- Stormwater: MWQI #1, 17
- Wetlands: MWQI #20
- WWTP: UV plant, primary plant, secondary plant effluent

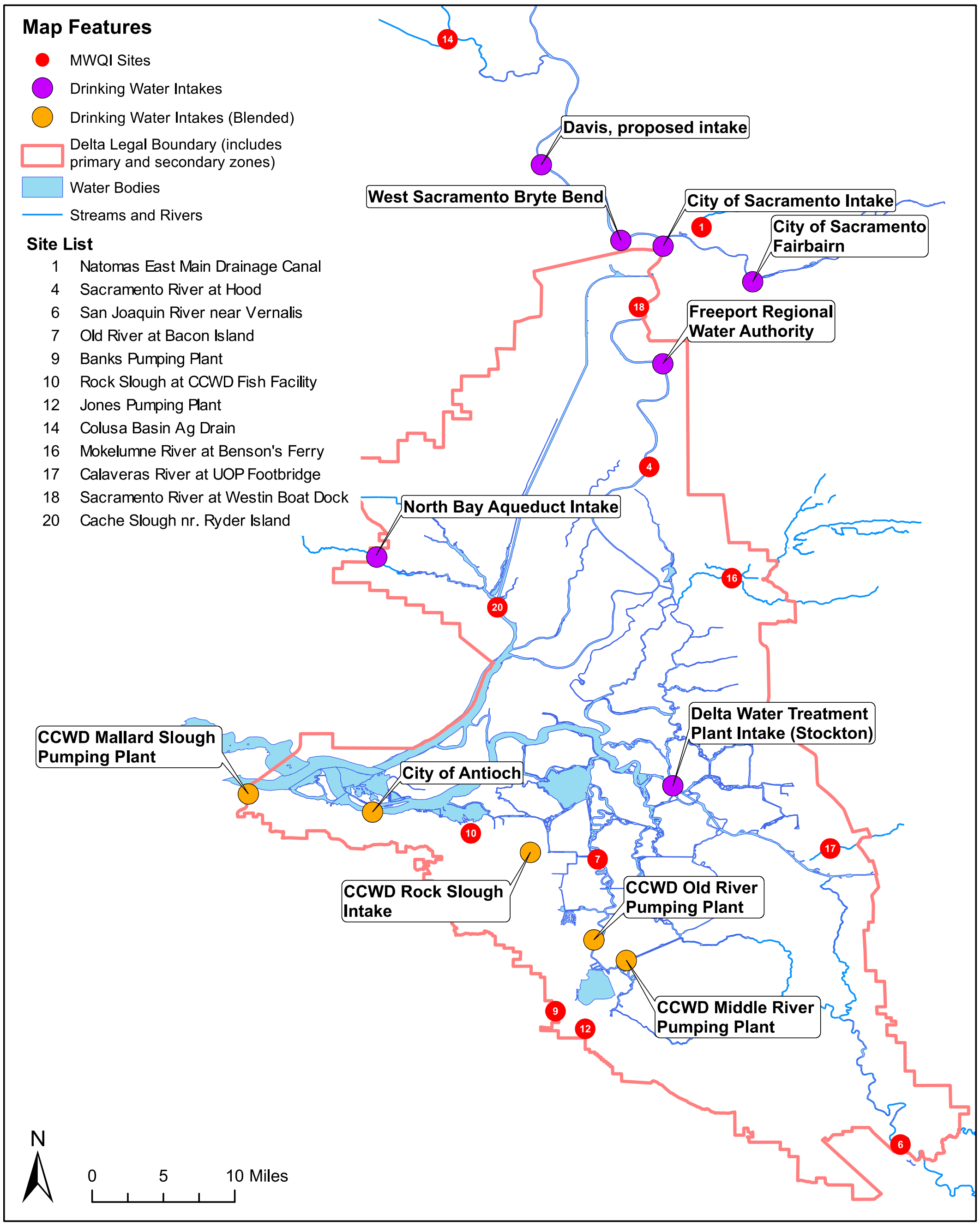
Cost Estimate for Addition of Area-focused Studies of Sources, Infectivity, and Hydrodynamics in Year 2

Estimated additional cost for Year 2 special studies.

Special Study Component	Estimated Additional Cost	Note
Source Monitoring	None to RMP	It is expected that sources within the study-area would collect and analyze *Cryptosporidium* and *Giardia* samples to rule out their contribution. Performed as TBD in-kind contribution.
Microbial Source Tracking	$22,500	Assumes six samples collected over six events
Infectivity Monitoring	$24,750	Assumes six samples collected over six events
Sample Collection	None to RMP	Incremental in-kind contribution from MWQI for collection of additional samples at $5,000 to $10,000
Administration, Coordination, and Reporting	None to RMP	Same as Year 1 in-kind contribution from CVDWPWG
Fate and Transport	TBD; minimum $250,000	The subcommittee deferred developing specific costs pending collection of additional data and literature research. Without additional data, the feasibility of the study could not be adequately assessed. A smaller pilot scale (i.e., bench-top) study may first be necessary.
Total Cost to RMP	**$47,250**	See text for additional discussion of in-kind contributions

Monitoring Sites

The map below shows the locations of the LT2 intake sampling along with the ambient locations. Ambient sites are co-located with existing MWQI sites as shown. Some sites are upstream of the Delta, but could influence water quality at the drinking water intakes or are representative of larger areas with the same land uses.



Ambient monitoring locations.

Proposed Sites	**Latitude**	**Longitude**	**Reasons for selection**
Colusa Basin Ag Drain	38.80197	-121.72552	Source representation (agriculture)
Natomas East Main Drainage Canal	38.61110	-121.46730	Source representation (stormwater, agriculture)
Sacramento River at Westin Boat Dock	38.53003	-121.53091	Proximity to intakes
Sacramento River at Hood	38.36691	-121.52037	General characterization
Cache Slough near Ryder Island	38.22500	-121.67481	Source representation (wetlands)
Mokelumne River at Benson's Ferry	38.25461	-121.43658	Input to Delta
Calaveras River at UOP Footbridge	37.98003	-121.33648	Source representation (stormwater)
Rock Slough at CCWD Fish Facility	37.99550	-121.70180	General characterization
Old River at Bacon Island	37.96910	-121.57290	General characterization
Banks Pumping Plant	37.81480	-121.61573	Export from Delta
Jones Pumping Plant	38.09627	37.79690	Export from Delta
San Joaquin River near Vernalis	37.67556	-121.26417	Input to Delta

Example Data Products

The data products for Year 1 of the characterization study will include a summary table to identify bin changes for each intake compared to the 2007 assessment, including a rolling average maximum and bin level assignment (**Example 1**). In addition, the ambient data will be summarized to characterize conditions near intake locations where changes in bin levels were observed. The data product to summarize ambient conditions will include tabulated (**Example 2**) and mapped (**Example 3**) summaries of ambient concentrations in the vicinity of observed bin level changes. Additional scatter plots and distributional or trend plots will be prepared to compare sites or events as shown in **Example 4**.

Data Product Example 1. Historic and current estimated bin levels and trigger assessments for Delta drinking water agencies.

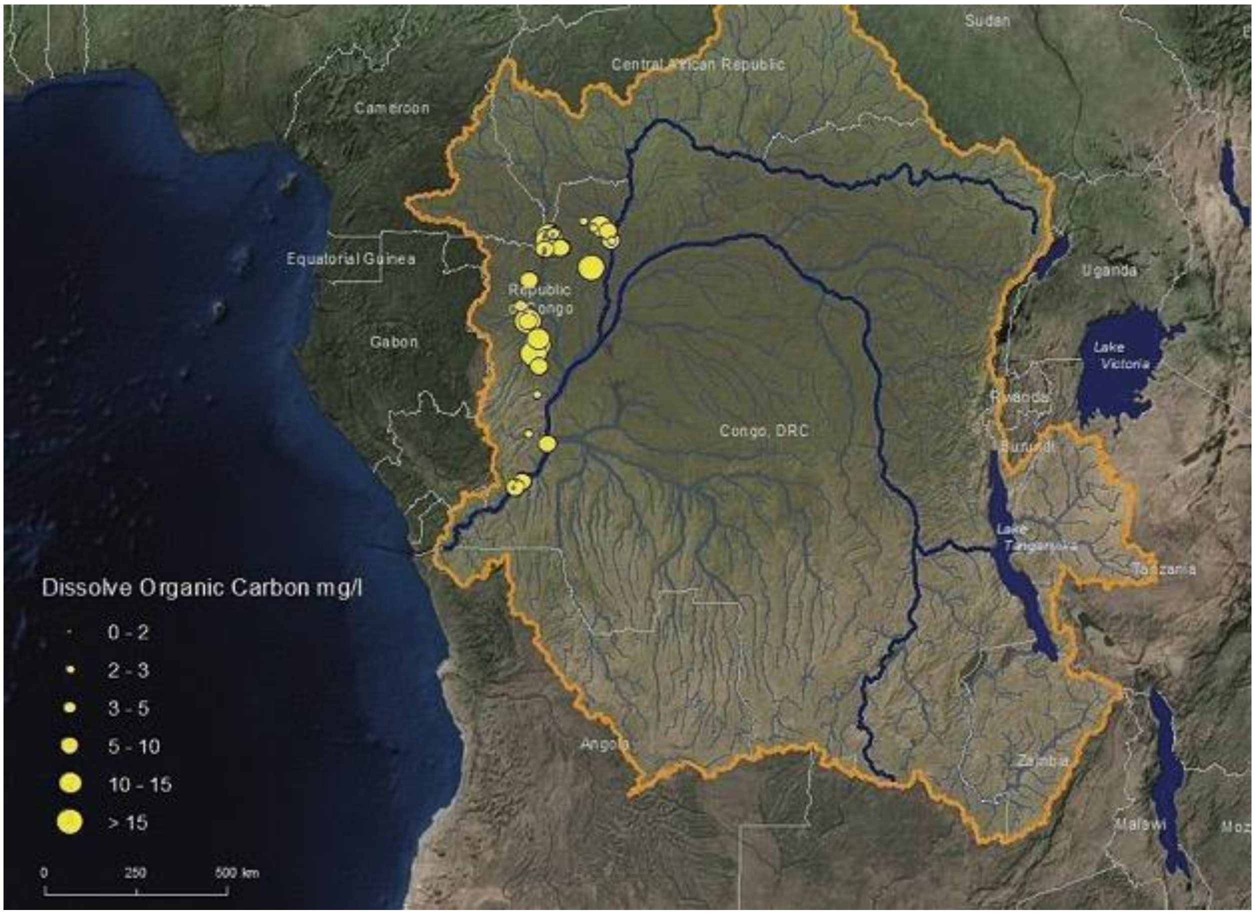
Water Agency Facility	2007 Bin Level	2015-17 Maximum Annual Running Average	Percent Detected Cryptosporidium	Estimated 2015-17 Bin Level	Trigger Exceedance Assessment
Intakes with Single Source Water					
Davis/Woodland/UC Davis	NA				
West Sacramento	1				
City of Sacramento (Sacramento River)	1				
City of Sacramento (Fairbairn)	1				
Freeport Regional Water Authority	1				
North Bay Aqueduct Intake	1				
Delta Water Treatment Plant Intake (Stockton)	1				
Intakes with Blended Source Water					
City of Antioch	1				
Contra Costa Water District	1				

Data Product Example 2. Ambient concentrations of *Cryptosporidium* at ambient sites near intake locations with bin changes.

Ambient Monitoring Site	Average Concentration	Maximum Concentration	Minimum Concentration	Percent Detected
MWQI #14				
MWQI #1				
MWQI #18				
MWQI #4				
MWQI #20				
MWQI #16				
MWQI #17				
MWQI #10				
MWQI #7				
MWQI #9				
MWQI #12				
MWQI #6				

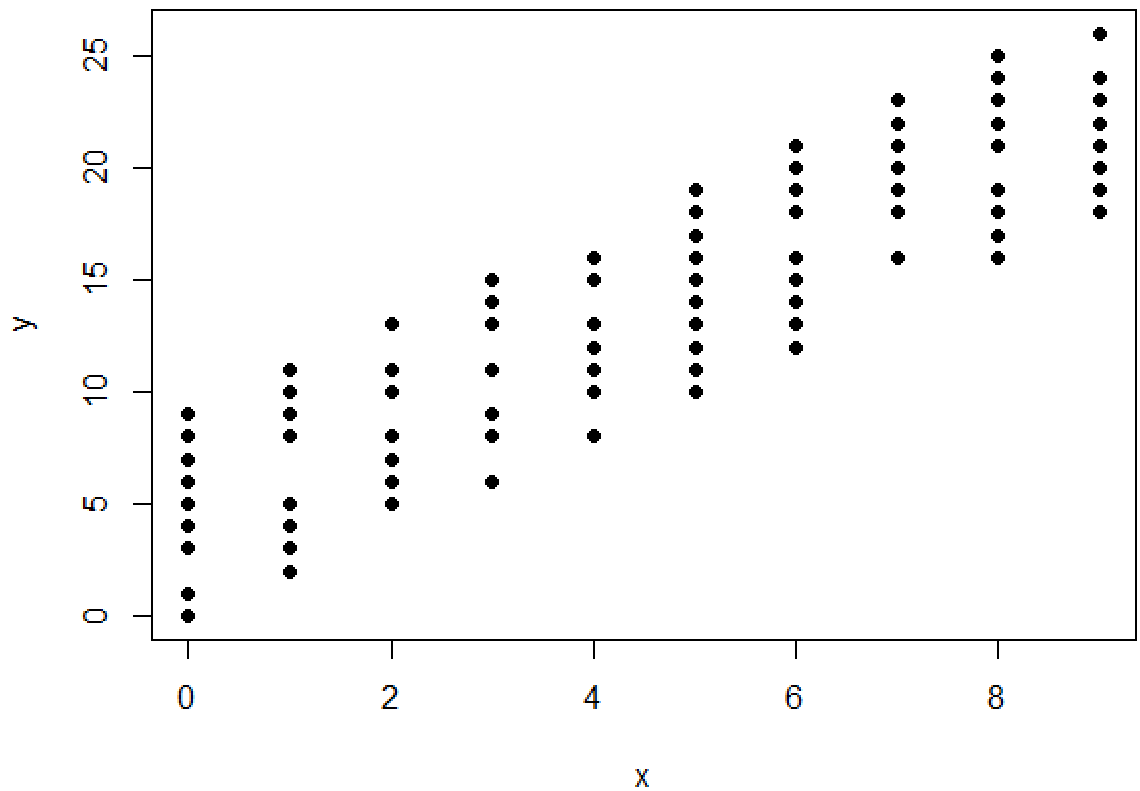
Data Product Example 3. Example map for concentrations and percent detection of *Cryptosporidium*.

Map with data summary to indicate ambient concentrations and percent detection (dot size, etc.)



Data Product Example 4. Example plot for observed *Cryptosporidium* at drinking water intakes and ambient locations.

Scatter plot with visualization of all data to display distribution by site, additional plots to show distribution by month; also for *Giardia*



Year 2 Special Study Data Products

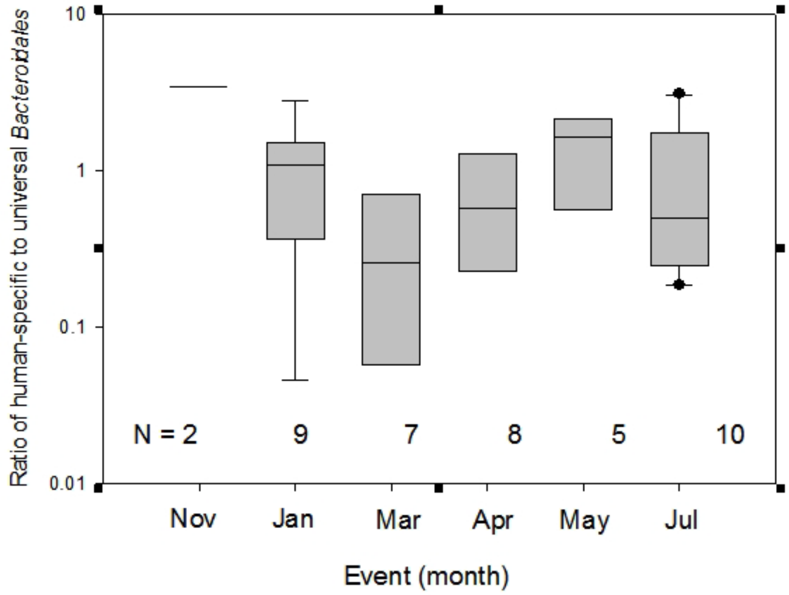
The data products for the Special Studies conducted during Year 2 of the Pathogen Study will include a tabular summary of infectivity rates (oocysts/infection) for ambient waters and source waters for infectivity assessments (**Example 5**). Microbial source tracking data will be summarized in tables or graphs of the relative percent contribution by host of the total *Bacteroidales* at each site and time point (**Example 6**). Summaries would be developed of the monthly hydrodynamic fingerprinting, with estimates of the relative volumetric comparison from sources to the location of the bin level change (**Example 7**).

Data Product Example 5. Concentrations of *Cryptosporidium* and percent infectious *Cryptosporidium* at ambient sites and in source waters.

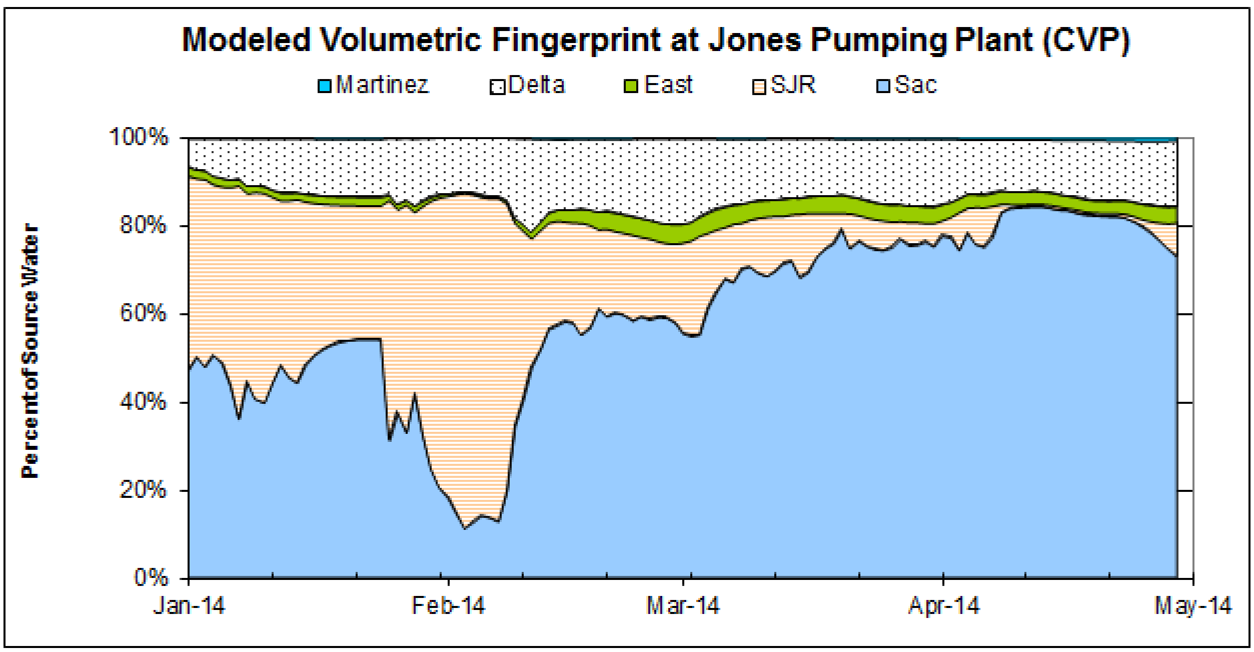
Location		% Positive for *Cryptosporidium*		Minimum *Cryptosporidium* Concentration		Maximum *Cryptosporidium* Concentration		Mean *Cryptosporidium* Concentration		Mean % Infectious
	n	Total	Infectious	Total	Infectious	Total	Infectious	Total	Infectious	
TBD Based on detection in Year 1	6									

Data Product Example 6. Example[10] of figure showing relative percent contribution of human-specific *Bacteroidales*

[10] from Sirikanchana, K., Bombardelli, F., Wang, D., Wuertz, S. 2008. Monitoring and Modeling Non-Point Source Contributions of Host-Specific Fecal Contamination in San Pablo Bay. UC Water Resources Center Technical Completion Report Project No. WR1015.



Data Product Example 7. Example of figure showing volumetric fingerprint at an intake location.



Target Parameters

Pathogen Monitoring	
Constituent	**Reporting Group**
Cryptosporidium	Pathogens
Giardia	Pathogens