RMP
REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

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Regional Monitoring Program for Water Quality in San Francisco Bay

2017 Detailed Workplan and Budget

Approved
11/1/16

SFEI | AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER
4911 Central Ave, Richmond, CA 94804, p: 510-746-7334 f: 510-746-7300

Summary

In 2017 the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) is entering its 25th year of collecting data and communicating information to support water quality management decisions. This Detailed Workplan and Budget describes the activities that will be completed in 2017 and their proposed funding levels.

The overall revenue and budget for 2017 are shown in Table 1 and Figures 1-2. The planned expenses are less than the expected revenue and excess revenue will be contributed to Program reserve funds for use in future years.

Table 1: Bay RMP 2017 Budget by Task.

	Direct Cost	Labor	Subcontract	Grand Total
1. Program Management	$6,000	$388,000		$394,000
2. Governance	$67,000	$203,000		$270,000
3. QA and Data Services	$0	$175,000	$10,000	$185,000
4. Annual Reporting	$56,500	$120,000	$40,000	$216,500
5. Communications	$28,500	$129,500	$7,000	$165,000
6. S&T Monitoring	$39,000	$210,300	$829,000	$1,078,300
7. Special Studies	$8,900	$1,194,385	$111,550	$1,314,835
8. Unallocated		$1,113		$1,113
Grand Total	$205,900	$2,421,298	$997,550	$3,624,748
Revenue				$3,760,738
Contributions to Reserve Funds				($135,990)
Planned Surplus (Deficit)				$0

This Detailed Workplan and Budget report is divided into four sections that provide details on the:

- 2017 Revenue
- 2017 Programmatic Tasks
- 2017 Status and Trends Monitoring
- 2017 Special Studies

The workplan also establishes the deliverables that will be produced for each line item of the budget. RMP staff will report on progress toward completing these deliverables throughout the year using a standardized “stoplight” report.

The Steering Committee approved this workplan and budget on November 1, 2016.

Figure 1: Bay RMP 2017 Revenue and Expenses.

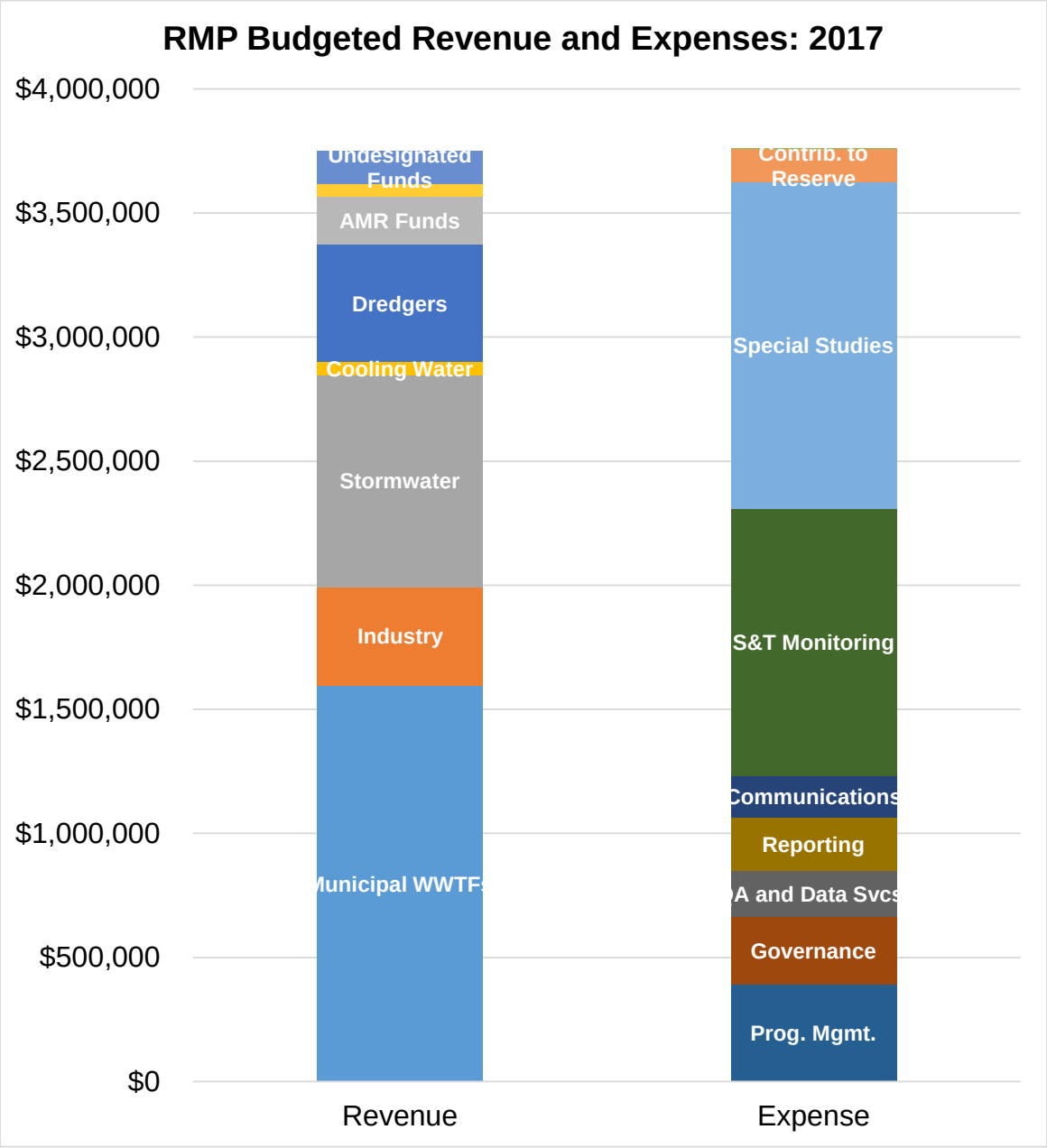
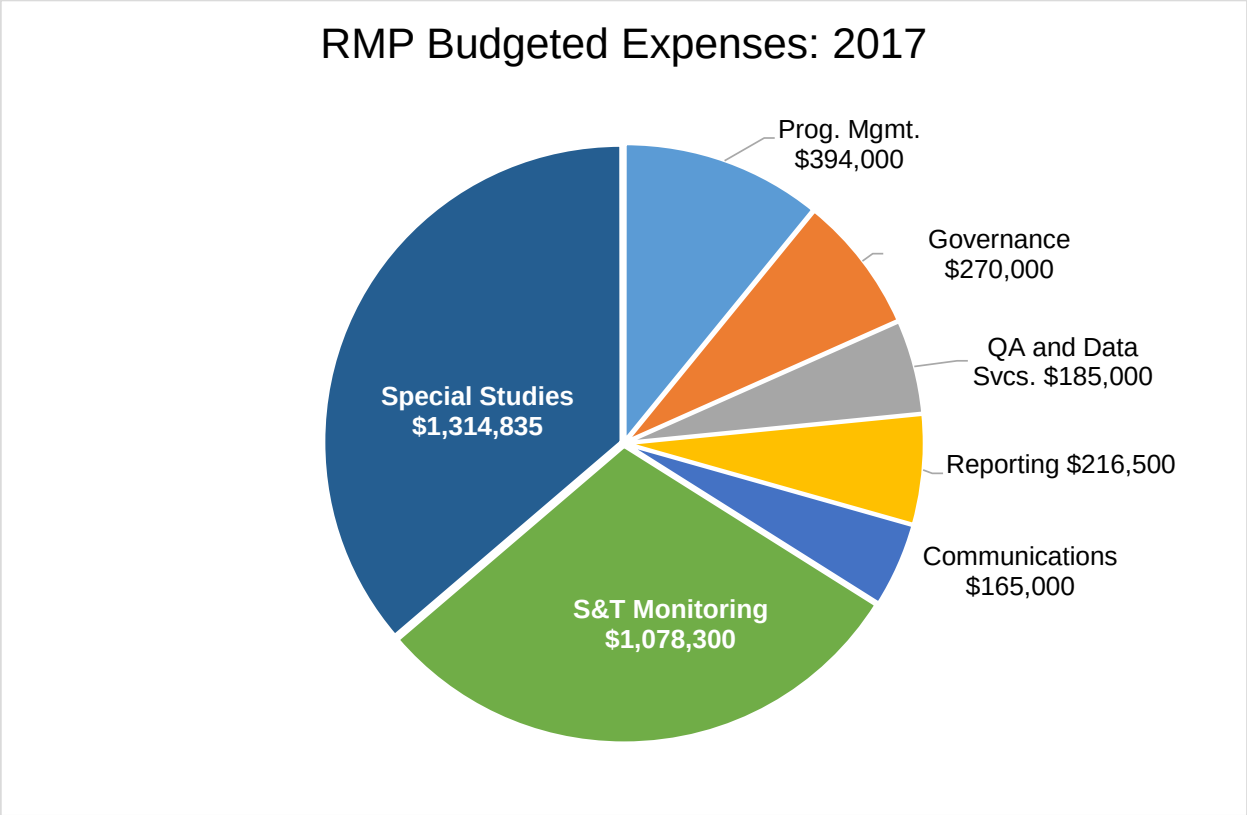


Figure 2: Bay RMP 2017 Budget by Task.



2017 Revenue

The total revenue for the RMP in 2017 is $3,761k. The breakdown of this revenue between participant fees, interest income, designated reserve funds, and undesignated reserve funds is shown in Table 2. The manner in which the fees are supposed to be divided up between Program Participants is shown in Figure 3.

a. Participant Fee Revenue

The target fee revenue for the RMP in 2017 is $3,373k. Fees were increased by 3% relative to the 2016 budget as approved by the Steering Committee on November 13, 2014. The actual fees collected in 2017 will be $254k below the target fees. This variance is because of a reduction in the fees paid by cooling water dischargers and a shortfall in the fees paid by dredgers.

The last remaining cooling water discharger to the Bay is phasing out of operation. On April 21, 2015, the Steering Committee approved a step-wise reduction in fees for cooling water participants from 4% of RMP fees in 2015 to 2% in 2016, 1.5% in 2017 and 0.5% in 2018. Therefore, for 2017, the cooling water fees will be reduced, resulting in $91k less revenue for the RMP.

Dredgers are responsible for 18% of the RMP fees (not including the lost cooling water fees), which would amount to $634,579. The algorithm used to collect the fees is based on the volume of dredged material that is disposed in the Bay. However, the volume of dredged material disposed in the Bay -- and the fees paid to the RMP by dredgers -- have been declining over time in accordance with sediment management plans. It is expected that dredgers will actually pay $472k in 2017, leaving a deficit of $163k. There is no money left in the Dredger Reserve Fund (extra fees paid by dredgers in previous years) to cover this shortfall. Most of this shortfall ($150k) is attributed to a federal interagency transfer between the U.S. Army Corps of Engineers and the U.S. Geological Survey that has not been adjusted for inflation since 1993.

b. Interest Revenue

RMP funds earn interest from the Local Agency Investment Fund (LAIF). For the 2017 budget, $10k in interest revenue was assumed, which is consistent with previous budgets.

c. Designated Reserve Funds

i. Dredger Reserve Fund

Dredging activity in the Bay is variable over the years. In years where there is lots of activity, any fees paid by dredgers that are greater than the target fees are stored in the Dredger Reserve Fund. These funds are held in reserve and can only be used to pay for shortfalls in dredger fees in future years. As mentioned earlier, the balance of the Dredger Reserve Fund is zero.

ii. Set-Aside Funds

The RMP uses designated funds -- called "Set-Asides" -- to smooth out the year-to-year expenses of the Status and Trends program. Rather than having a spike in expenses in one year, the Steering Committee designates some funds to be set aside in light years and withdrawn in years with lots of monitoring. In 2017, the Status and Trends monitoring is light so funds will be contributed to the set-asides, not withdrawn. The amount contributed will be presented in the Status and Trends Expenses section.

Aside from the Status and Trends set-aside, the Steering Committee committed $50,000 to a WQIF grant proposal to develop a sediment monitoring strategy for the Bay. These funds were placed in a designated set-aside pending the grant award. Now that the grant has been awarded, these funds will be added as revenue to the 2017 budget. An equal amount of expense will be added as a special study.

d. Undesignated Reserve Funds

The RMP maintains a balance of Undesignated Funds for contingencies. Higher than anticipated revenues and elimination or reduction of lower priority elements sometimes lead to accumulation of funds that can be used for high priority topics at the discretion of the Steering Committee. It is the policy of the RMP to maintain a minimum balance of $200,000 in Undesignated Funds as a reserve for unanticipated urgent priorities.

A total of $133,000 of Undesignated Funds are proposed to be used for the 2017 budget. The purpose of this request is to combine the allocations for margins studies for 2017 and 2018 to fund the South Bay Margins Sediment Study. The $133,000 will be paid back to the Undesignated Funds account in 2018 from fees.

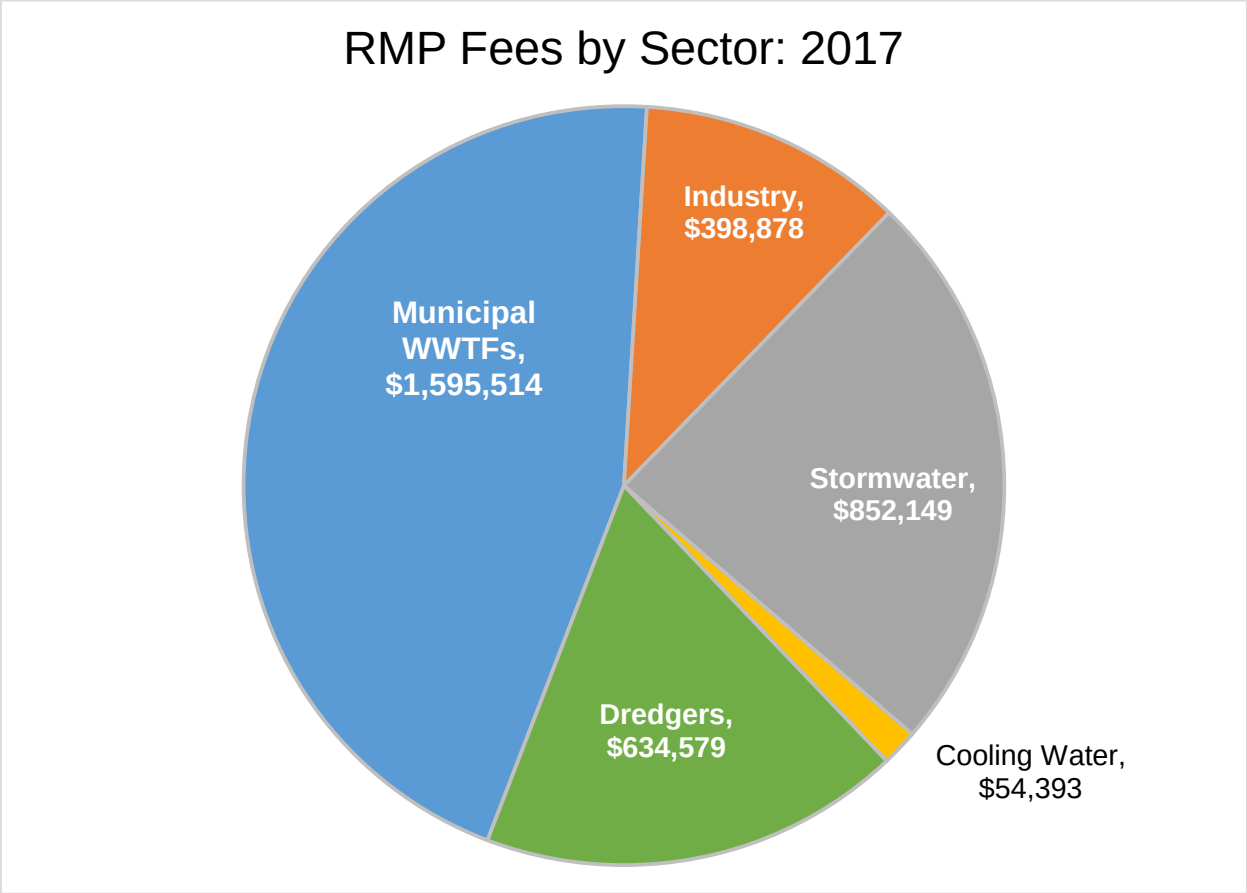
e. Alternative Monitoring Requirement Funds

The RMP received $235k of supplemental funding from municipal wastewater agencies for FY17. The intended use of these funds is for emerging contaminants studies. The Steering Committee approved the use of $194,725 of these funds for four CEC special studies. Therefore, this amount will be added to the 2017 budget as revenue.

Table 2: 2017 RMP Revenue

Revenue Category	**Subcategory**	**2017 Budget**
Participant Fees	Municipal	$1,595,514
Participant Fees	Industrial	$398,878
Participant Fees	Stormwater	$852,149
Participant Fees	Cooling Water	$54,393
Participant Fees	Dredgers	$634,579
Participant Fees	Dredgers - expected surplus (deficit)	-$162,500
Interest Income	Interest Income	$10,000
Designated Reserve Funds	Set-Aside Funds for S&T Monitoring	$0
Designated Reserve Funds	Dredger Reserve Funds	$0
Designated Reserve Funds	Set-Aside Funds for Monitoring Contingency	$0
Designated Reserve Funds	Set-Aside Funds for Sediment Strategy	$50,000
Undesignated Reserve Funds		$133,000
AMR Funds		$194,725
TOTAL REVENUE		$3,760,738

Figure 3: Bay RMP 2017 Fee Allocations for Program Participants.



2017 Programmatic Tasks

RMP expenses fall into three broad categories: programmatic expenses, Status and Trends monitoring, and special studies. This section details the budgets for programmatic expenses for 2017.

The programmatic budget covers the following tasks:

- Program management
- Governance
- Quality Assurance (QA) and Data Services
- Annual Reporting
- Communications

The total cost to implement these tasks in 2017 is $1,230,500. This budget is $68,500 less than the 2016 budget. The major reasons for the cost reductions are summarized in Table 3. More details about each of these tasks are provided in the following sections, on Table 4, and in Appendix A. Appendix A contains descriptions for each subtask or expense, budget justifications, and the expected deliverables.

Table 3: RMP 2017 Programmatic Budget Compared to 2016 Budget

	2016 Budget	2017 Budget	Difference	Comments
1. Program Management	$393,000	$394,000	$1,000	
2. Governance	$271,500	$270,000	-$1,500	Cut costs for SC and TRC meetings. Increased costs for WG meetings and external advisors.
3. QA and Data Services	$311,000	$185,000	-$126,000	Fewer datasets to manage. Data mgmt for S&T monitoring ($55k) budgeted with data collection.
4. Annual Reporting	$164,000	$216,500	$52,500	Increased costs are because the Pulse report will cost $135k which is approx. $50k more than the RMP Update report.
5. Communications	$159,500	$165,000	$5,500	Increased costs for 25th Anniversary communications.
Total	$1,299,000	$1,230,500	-$68,500	Cumulative reduction of 5% of PM costs.

1. Program Management

Program management subtasks include program planning, contract and financial management, technical oversight, internal and external coordination, and administration. The total expense for these tasks is $394,000. Approximately half of the cost for this category is fiduciary oversight of program expenses and contractors. In past years, there has typically been a small balance ($10k) left in this budget at the end of the year. These extra funds will be used, if needed, to prepare contracts for SEP-funded projects before the SEP funds are available.

The major deliverables that will be completed with these funds are: the Multi-Year Plan, the Detailed Workplan, quarterly financial updates to the Steering Committee, and quarterly tracking of deliverables and action items. Funds for technical oversight allow for internal review by senior staff of the many reports, presentations, posters, workplans, memos, and other communications coming out of the RMP. The funds for external coordination cover participation in meetings with external partners to coordinate programs and leverage RMP funds (e.g., coordinating work on the Pulse Report and other reports, coordination with SCCWRP, and serving as liaison to the Delta RMP and other RMPs).

The budget for this task is approximately the same as it was in 2016.

2. Governance

Governance subtasks include convening, coordinating, and facilitating Steering Committee, Technical Review Committee, and Workgroup meetings. Tasks include preparing agendas, agenda packages, participating in meetings, writing meeting summaries, action item follow-up, reviewing minutes from past meetings, coordination with committee chairs, and honoraria and travel for external advisors. The total budget for these tasks is $270,000.

The major deliverables that will be completed with these funds are: quarterly Steering Committee meetings, quarterly Technical Review Committee meetings, and 8 Scientific Workgroup meetings with external science advisors in the spring.

The budget for the Steering Committee and TRC meetings is $95k, whereas the budget for the workgroups and science advisors is $175k. Workgroup meetings are critical for the RMP planning process. In 2015 and 2016, the budgets for workgroup meetings were exceeded but the budgets for Steering Committee and TRC meetings had surpluses. Therefore, the 2017 budget allocates more of the funds to the Workgroup meetings. Additional meetings of a Microplastic Workgroup and a Sediment Strategy group are expected.

3. QA and Data Services

Quality assurance is a critical foundation for the scientific investigations of the RMP. The major quality assurance tasks for 2017 are keeping the Quality Assurance Project Plan up to date, preparing QA summaries for datasets, and conducting interlaboratory comparison tests. In addition to processing new data, the Program needs to maintain the millions of records generated since it began in 1993. Database maintenance includes incorporating updates and corrections to

data, including re-analyzed results and updates implemented by CEDEN/SWAMP. RMP staff also maintain and enhance web-based data access and visualization tools such as CD3 and an automated system to handle data submittals from the laboratories.

The total cost for these tasks will be $185k. This budget is $126k less than it was in 2016, but not all of this amount is true cost savings. The budgets for managing the 2017 Status and Trends datasets have been included with the other S&T costs. Other cost savings come from having fewer datasets to manage and being more efficient with the online tools.

4. Annual Reporting

A *Pulse of the Bay* report will be produced in 2017, to be released at the Annual Meeting in October. The *Pulse* is a more expensive product than a *RMP Update* report that was prepared in 2016 ($60,000 for the 2016 RMP Update vs $125,000 for the 2015 *Pulse*). The theme of the *Pulse* report is still being decided but the report will certainly have a focus on the RMP's 25th Anniversary. Therefore, some additional funds have been budgeted for developing that content.

Tasks related to the Annual Meeting include developing the meeting agenda, managing logistics, advertising about the meeting, managing attendee registration, preparing presentations, and staffing the meeting. The budget for 2017 assumes that the Annual Meeting will be held in conjunction with the State of the Estuary Conference. However, the Steering Committee may decide to change the venue and hold a separate meeting, which is typically less expensive.

The total cost for these tasks will be $216,500. This budget is $52,500 more than it was in 2016. The major cost increase came from planning for a *Pulse* report instead of a *RMP Update* report.

5. Communications

Communications tasks will implement the plans included in the RMP Communications Strategy, approved by the Steering Committee in July 2014. Tasks will include the distribution of RMP information to stakeholders, natural resource managers, and the public through multiple media channels (e.g., website, publications, email newsletters, fact sheets, social media, etc.). In 2017, the RMP will continue to provide support for *Estuary News* ($15,000) plus staff time to plan and review content. An additional $20k has been budgeted to plan and implement special activities for the RMP's 25th Anniversary.

Stakeholder engagement is critically important to addressing the information needs of RMP participants. Tasks include preparing for and attending RMP stakeholder meetings (e.g., BACWA, BASMAA, BPC, LTMS, WSPA, and RB2) as well as communicating directly with stakeholder representatives.

Other communications tasks include responding to inquiries for RMP data and reports, including press calls, and producing summary information on important topics in convenient formats. Participation in workshops and conferences for SWAMP, SETAC, ACS, and other

professional organizations allows sharing of RMP information, gathering of information from other investigators on the latest advances in monitoring and understanding, and identification of opportunities for collaboration with other organizations. Presentations at local meetings and to local audiences are also important for collaboration and information dissemination to scientific partners. Keeping the website up to date is another important component of communication.

A budget of $20k has been planned for this task (a $5k increase) to fund getting more information on the website and making it more useful for stakeholders.

The total cost for these tasks will be $165,000. This budget is $5,500 more than it was in 2016.

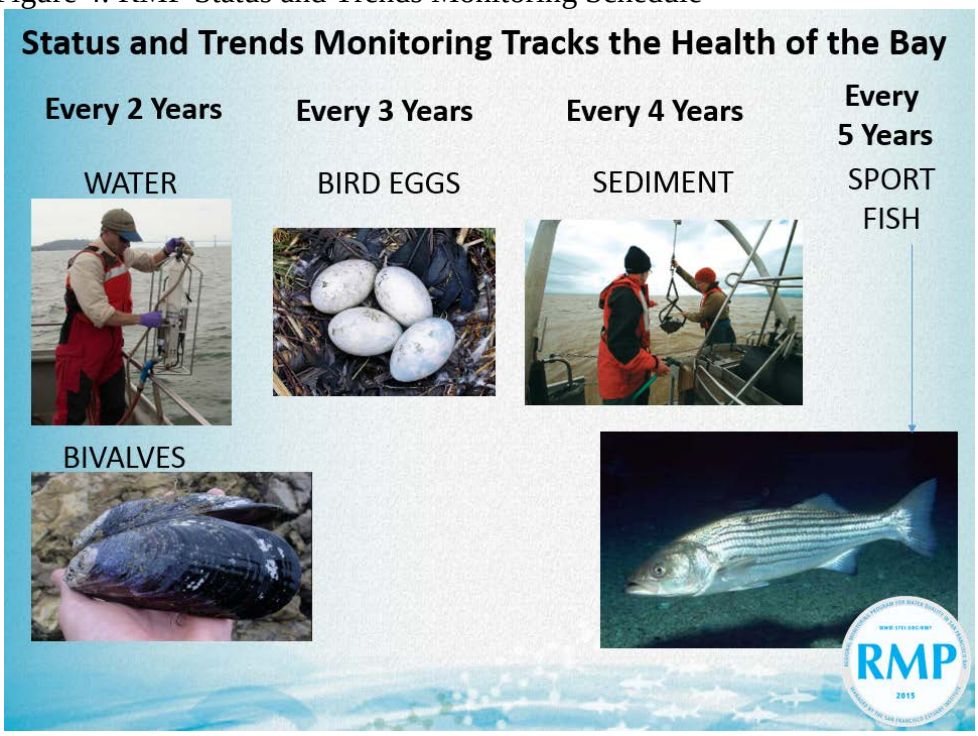
Table 4: Bay RMP 2017 Programmatic Budget by Subtask. Detailed descriptions of the tasks, budget justifications, and deliverables are provided in Appendix A.

Task	Subtask	Direct Cost	Labor	Subcontract	Grand Total
1. Program	A. Program Planning		$40,000		$40,000
Management	B. Contract and Financial Management	$1,000	$169,000		$170,000
	C. Technical Oversight		$50,000		$50,000
	D. Internal Coordination		$80,000		$80,000
	E. External Coordination		$40,000		$40,000
	F. Administration	$5,000	$9,000		$14,000
2. Governance	A. SC meetings	$2,000	$48,000		$50,000
	B. TRC meetings	$2,000	$43,000		$45,000
	C. WG meetings	$3,000	$112,000		$115,000
	D. External Science Advisors	$60,000			$60,000
3. QA and Data	A. Quality Assurance System	$0	$30,000	$10,000	$40,000
Services	B. Online Data Access: CD3		$65,000		$65,000
	C. Database Maintenance		$50,000		$50,000
	D. Updates to SOPs and Templates		$30,000		$30,000
4. Annual Reporting	A. Pulse Report	$30,000	$70,000	$35,000	$135,000
	B. Annual Meeting	$26,500	$50,000	$5,000	$81,500
5. Communications	A. Communications Plan Implementation	$18,000	$32,000		$50,000
	B. Stakeholder Engagement		$28,000		$28,000
	C. Responses to Information Requests		$12,000		$12,000
	D. Fact Sheets and Outreach Products	$500	$7,500	$2,000	$10,000
	E. Presentations at Conferences and Meetings	$10,000	$30,000	$5,000	$45,000
	G. RMP Website Maintenance		$20,000		$20,000
Grand Total		$158,000	$1,015,500	$57,000	$1,230,500

2017 Status and Trends Monitoring and Reserve Funds

In 2014, the Steering Committee and Technical Review Committee revised the Status and Trends (S&T) sampling schedule to free up resources. The current schedule is shown in Figure 4.

Figure 4: RMP Status and Trends Monitoring Schedule



In 2017, water and margins sediment sampling will occur. In addition, the RMP provides annual support to the USGS for suspended sediment and nutrient monitoring. This support will continue in 2017. The total cost for S&T monitoring in 2017 will be $1,078,300.

Another $135,990 will be contributed to reserve fund accounts. This total amount has three components. First, $125,000 will be added to the Designated Reserve Fund for S&T Monitoring to offset future S&T costs. Second, $10,990 will be moved to the Designated Reserve Fund for Monitoring Contingencies. These funds were used in 2016 for an interlaboratory calibration study. This fund will be replenished to its normal balance of $50,000.

More information about each of the S&T tasks is provided in the line item budget (Table 5) and the sections below.

6. Status and Trends
A. Field Work and Logistics

A. Field Work and Logistics ($166,000)

This task includes work by SFEI to assist with sampling and coordination ($50k); a subcontractor (Applied Marine Sciences) to plan cruise logistics, collect samples, ship samples to laboratories, and manage the sample archive ($80k); funds for renting the research vessel (the R/V *Turning Tide*) ($30k); and funds for other miscellaneous items ($6k).

B. Continuous Monitoring of Suspended Sediment ($250,000)

This work is led by Dr. David Schoellhamer of the USGS California Water Science Center. USGS maintains five suspended sediment stations in the Estuary with RMP funding (i.e., Mallard Island, Richmond Bridge, Alcatraz, Exploratorium, and Dumbarton Bridge). This funding leverages suspended sediment monitoring at 2 other stations (Benicia Bridge, Carquinez Bridge) and salinity at 8 stations that are funded by other partners. In addition, the RMP has used Special Studies funding to add dissolved oxygen sensor to 6 stations and nutrient parameter sensors to 3 stations. Discussions are underway to determine how to maintain the existing monitoring scheme in light of increasing costs and the available budget, which has been fixed at $250,000 since 1993. Funding is provided by the U.S. Army Corps directly to USGS.

C. Monthly Basic Water Quality ($229,000)

This work is led by Dr. Jim Cloern of the USGS in Menlo Park. The study performs monthly water sampling to map the spatial distributions and temporal trends of basic water quality parameters along the entire Bay-Delta system. Measurements include salinity, temperature, dissolved oxygen, suspended sediments, and phytoplankton biomass. This basic information is required to follow the seasonal changes in water quality and estuarine habitat as they influence biological communities and the distribution and reactivity of trace contaminants.

D&E. 2017 Water Cruise Laboratory Expenses and Data Management ($59,300)

The Status and Trends schedule calls for water sampling every other year. Water samples from 22 random and targeted sites will be collected and sent to laboratories for analyses of metals, conventional parameters, and aquatic toxicity. The expected laboratory costs for the analyses are $45,000. The expected cost to manage the data from this sampling effort is $14,300.

F&G. Margins Sediment Sampling: Data Analysis and Reporting ($290,000)

In 2015, funds freed up by reductions in water and open-Bay sediment monitoring were used to sample sediment on the margins of Central Bay. Sediment samples were collected from 40 sites on the Bay margins and are being analyzed for mercury, PCBs, and trace metals. The budget for that study, including planning and report writing, was $260k.

The preliminary results of that study have were presented to the TRC in September 2016. The TRC supported collecting more sediment samples in the margin areas of Bay. The South

Bay rea was identified as the leading candidate for the next study area. The TRC also supported "doubling up" the margins funding for 2017 and 2018 to conduct one larger study because it is more efficient for field costs.

Therefore, a total of $260k have been budgeted for a South Bay Margins Sediment Study in 2017. These funds will be used to plan, implement, and report the results of the study. A more detailed study plan could not be prepared in time for this budget because the data from the 2015 study are still being analyzed. RMP staff and the TRC will prepare a detailed plan for Steering Committee approval before beginning the sampling. The only funds from this budget line that will be spent immediately are $10k for planning the study.

H. Global Passive Sampling Initiative

At the 2016 Emerging Contaminants Workgroup meeting, the Science Advisors recommended that the RMP become more involved with passive sampling. One of the ECWG advisors is part of the Global Aquatic Passive Sampling Network (AQUA-GAPS). This program is organizing a study that would install passive samplers for organic contaminants in estuaries and lakes around the world. The RMP can participate at low cost. The funding allocated to this study ($8k) is for shipping the passive samplers and a small amount of staff time to coordinate the work. There will be no analytical costs for the RMP. The budget assumes that deployment and retrieval of the samplers can be done from existing cruises or ships of opportunity.

I. Sample Archive ($51,000)

The RMP stores archives of sediment, bivalve, bird egg, and sport fish samples, as well as other miscellaneous samples, in archives for potential future analyses. Short-term archives are stored at Schaeffer's Meat and Storage in Oakland. Long-term archives are stored at NIST in Charleston, South Carolina. Costs in 2017 will cover continued storage fees for the archives ($40k) as well as labor to manage the archives and the archive database ($11k). In past budgets, the cost of the archives were spread out across multiple budget lines. All of these costs have been brought together in this budget line to show the full cost of this activity. In 2016, the RMP removed old samples from the short-term archives to reduce the monthly fees for storage. In 2017, RMP staff will plan for ways to strategically use the archives, both within the RMP and with academic partners.

J. Analysis of S&T Data ($15,000)

Every two years, following the collection of ambient water samples, measured concentrations are compared to site-specific objectives triggers for copper and cyanide. In other years, funds from this task will be used to support other analyses of S&T data, as requested and in support of development and publication of RMP manuscripts.

K. Annual Monitoring Report

At the end of the field season, RMP staff will prepare the Annual Monitoring Report, which will summarize the 2017 field sampling effort. The goal of the report is to document

where samples were collected and any complications during field sampling. The report will not contain any data analysis or results. Clear documentation of field sampling effort is part of the overall quality assurance system for the Program.

Contributions to Reserve Funds ($135,990)

S&T Monitoring costs are variable year over year. In order to smooth out the annual cost of the program, contributions to a Designated Reserve Fund for S&T Monitoring are made in years with lower direct costs. 2017 is a lower than average cost year. Based on a 10-year plan for S&T, $125,000 needs to be contributed to the Designated Reserve Fund in 2017.

An additional $10,990 in unbudgeted revenue will be moved to the Designated Reserve Fund for Monitoring Contingencies. These funds were used in 2016 for an interlaboratory calibration study. This fund will be replenished to its normal balance of $50,000.

Table 5: Bay RMP 2017 Status and Trends Budget by Subtask.

Task	Subtask	Direct Cost	Labor	Subcontract	Grand Total
6. S&T Monitoring	A. Field Work and Logistics	$6,000	$50,000	$110,000	$166,000
	B. USGS Sacramento Support			$250,000	$250,000
	C. USGS Menlo Park Support			$229,000	$229,000
	D. 2017 Water Cruise Lab Expenses			$45,000	$45,000
	E. 2017 Water Cruise Data Mgmt		$14,300		$14,300
	F. 2017 South Bay Margins Sediment Study	$5,000	$75,000	$180,000	$260,000
	G. 2017 South Bay Margins Sediment Study Data Mgmt		$30,000		$30,000
	H. Global Passive Sampling Initiative	$3,000	$5,000		$8,000
	I. Sample Archive	$25,000	$11,000	$15,000	$51,000
	J. Analysis of S&T Data		$15,000		$15,000
	K. Annual Monitoring Report		$10,000		$10,000
Grand Total		$39,000	$210,300	$829,000	$1,078,300
Contributions to Reserve Funds	S&T Monitoring Set Aside Contribution				$125,000
	Monitoring Contingency Fund Replenishment				$10,990
	Total				$135,990

2017 Special Studies

The following studies have already been reviewed by the Technical Review Committee and Steering Committee and approved for incorporation into the 2017 RMP workplan.

The total costs for special studies in 2017 will be $1,315k. Additional details on each of the studies are provided below, in the line item budget (Table 6), and in the full proposals that were presented to the SC in July 2016 (available at: https://drive.google.com/open?id=0B-DCvkdKIAt2SFFpYUFLaHhaQWc).

Nutrients ($373,000)

Overview

In FY 2017, RMP special study funds will again be combined with $880k of Nutrient Watershed Permit funds for conducting nutrient-related science and monitoring. The two projects listed below will receive RMP funding, and are among the highest priority projects for FY 2017 that were approved by the NMS Steering Committee in June 2016 with science advisor and Nutrient Technical Workgroup input.

Moored Sensor Monitoring ($153,000)

While monitoring has occurred regularly in the Bay over the past 40 years, most of the data have been collected at weekly or monthly time intervals. Phytoplankton, nutrients, dissolved oxygen, and other parameters such as suspended sediment (which dictates the light available for phytoplankton growth) vary strongly over much shorter time scales (e.g., on an hourly basis) due to the daily cycle of photosynthesis and respiration in phytoplankton, mixing, biogeochemical processes, and tides. To better assess the Bay's condition on these time scales, and to collect high-frequency data to calibrate water quality models, the RMP launched a moored sensor network in 2013. Since 2013, a network of four stations have been installed south of the San Mateo Bridge as part of the core NMS moored sensor program. At each station, an instrument has been deployed that houses sensors for specific conductance (or salinity), temperature, depth, dissolved oxygen, turbidity, chlorophyll-a, fDOM, and phycocyanin. The sensors record a measurement every 15 minutes. During 2017, each of the sensor sites will be visited approximately every 3 weeks for servicing, calibration, and downloading data.

New funding requested for FY 2017 will be supplemented by remaining funds from FY 2016.

Moored sensor activities in 2017 will include:

- Complete Year 3 of monitoring open bay stations (San Mateo, Dumbarton Bridges) and Alviso Slough
- Complete Year 1 of slough/creek deployments, and extend through a second summer/fall/winter.

- Data analysis and quantitative mechanistic interpretations to identify factors contributing to observed conditions.
- Sensor network maintenance.
- Data management and QA/QC.

Deliverables:

1. Mid-fiscal year update to inform FY 2018 priorities (December 2016)
2. Summary of major observations in the NMS FY 2017 Annual Report and technical report(s) included as appendices to the annual report describing:
    a. Spatial/temporal variability in Lower South Bay / South Bay / open Bay and slough water quality (DO, chlorophyll, etc.)
    b. Mechanistic interpretations, including physical forcings (including exchange between pond ← → sloughs ← → Bay)
    c. Initial interferences related to the potential influence of anthropogenic nutrients on DO conditions at specific sites or in Lower South Bay margins more broadly, and the potential role of exchange with salt ponds on DO, phytoplankton biomass, and nutrient budgets in Lower South Bay

    (Draft June 2017; Final September 2017) – Review by Nutrient Technical Workgroup (NTW)

<u>Ship-based Nutrient Sampling ($220,000)</u>

Ship-based samples will be collected and analyzed for a range of nutrient-related parameters. This data is essential for basic condition assessment, model calibration, and improved understanding of nutrient behavior and nutrient-related effects in the Bay. Ship-based discrete samples will be collected by USGS aboard the R/V Peterson on ~12 full-bay cruises to 14 sites and an additional ~12 South Bay cruises.

Costs covered by NMS

- Nutrient analyses (USGS national lab)
- Analysis of integrated toxin samples (SPATT), discrete toxin samples, and algal pigments (at UCSC)
- Basic data QA/QC and basic reporting
- Additional staff support on cruises to support the collection of NMS related samples: inorganic nutrients, total nutrients, microscopy, algal pigments, and particulate algal toxins; spatially integrated toxin samples (SPATT)

Costs covered by USGS as part of their core program

- Collection of samples for chlorophyll and ancillary data (e.g., suspended particulate matter, dissolved oxygen, salinity)
- Vertical profiles for multiple parameters
- Underway flowthrough data collection (salinity, T, chla fluorescence, turbidity/optical backscatter)
- Program management, scientific oversight
- Data management for USGS parameters plus inorganic nutrients

Deliverables:

1. Results will be summarized in the NMS FY 2017 Annual Report (Draft June 2017; Final

September 2017) – review by NTW

Small Tributary Loadings Strategy[1] ($370,000)

The San Francisco Bay Hg and PCBs TMDLs call for reductions in loads by 50% and 90% by 2028 and 2030, respectively. In response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) called for a range of actions including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of loads of sediments and trace contaminants on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. These same needs were reflected in the Small Tributary Loading Strategy (STLS) (SFEI, 2009).

On November 19, 2015 the second MRP was issued and provided an updated set of management questions (SFRWQCB, 2015):

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5: Trends: What are the spatial and temporal trends in loads or concentrations?

Consistent with this new focus, the following tasks and deliverables will be completed:

<u>Small Tributaries Stormwater Characterization – Pollutants of Concern Reconnaissance Monitoring ($200,000)</u>

This study will support a characterization study in the winter of 2016-17 (water year 2017) to identify additional watersheds with high-concentration source areas for potential actions to reduce loads of PCBs and mercury. The wet weather field monitoring program will largely mimic, with the exception of some minor improvements, the program implemented during WY 2011 (McKee et al., 2012), WY 2015 (McKee et al., 2016, in SPLWG review), and WY 2016.

Monitoring Design:

- Collection of 1 composite stormwater sample per site collected during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using one of three manual sampling techniques employing clean hands protocols (D95, b-reel, and boom-truck water quality sampler at sites with larger watershed areas, DH81 water quality sampler, or an ISCO pumping sampler)

[1] SPLWG = Sources, Pathways and Loadings Workgroup. STLS = Small Tributary Loading Strategy Team.

- Collection of 1 settled suspended sediment stormwater sample per site collected during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using one or both of two remote sampling techniques (Hamlin or Walling tube)

Site Selection:

- A balance between two overarching rationale:
    - Nested sampling design to track sources upstream in known polluted areas to help better define source areas and management options.
    - Finding new polluted watersheds or sub-watershed areas (watershed locations near the Bay margin or further downstream than the source tracking approach).
- Other selection rationale:
    - Larger watersheds with an existing USGS gauge
    - Re-sampling potential false negatives especially where there is putative evidence
    - Contingency for resampling Guadalupe River for trends
    - Filling gaps along environmental gradients in relation to source areas (most specifically to support RWSM development [MQ4])

Number of sites:

- Dependent on site logistics, proximal site associations, analytes, budget and other factors, but likely 10-12 sites.

The 2017 analytes list be continued (PCBs, Hg, SSC, TOC, grainsize, salinity)

The draft report for this study will include the 2017 data and perhaps some more interpretative reporting including statistical analysis of the land use and source areas context and comparison to selected literature. The main objectives of the report will be to 1) document the outcomes of the remote sampler sub-study and describe the circumstances for its possible inclusion into future sampling programs; and 2) report and rank concentrations and particle ratios observed at each location and compare these to existing data.

Deliverables:

1. Collection of stormwater samples (October 2016-April 2017)
2. Report on Pollutants of Concern monitoring in WY 2017 (Draft December 2017; Final March 2018) -- Review by SPLWG and STLS.

<u>Regional Watershed Spreadsheet Model ($40,000)</u>

To accurately assess total contaminant loads entering San Francisco Bay, it is necessary to estimate loads from local watersheds. “Spreadsheet models” of stormwater quality provide a useful and relatively cheap tool for estimating regional scale watershed loads. These models can also be used to provide a quantification of the relative concentrations and loads between watersheds to help focus management, and possibly to help identify areas within watersheds for further investigation as part of the weight of evidence approach. Starting in 2010, a multi-year effort was undertaken to systematically develop and calibrate the Model. The development process has been documented through four previous progress reports. The Model was structured to use either a hydrology model or suspended sediment (SS) model as the basis for the pollutant models. The modeling effort also included linkages to other efforts by Bay Area Stormwater Management Agencies Association (BASMAA) and the RMP. Milestones achieved to date include:

- Developing and calibrating the hydrology model and the completion of pollutant profiles for PCBs, Hg, SS, Cu, Se, OC pesticides, and PBDEs (Lent and McKee, 2011; Lent et al., 2012),
- Improving GIS data about the sources of PCBs and Hg (McKee et al., 2014; Wu et al., in SPLWG review), and
- Improving the model calibration procedure to include analysis of modeling errors and output of the first reasonable model calibrations for PCBs (Wu et al., in SPLWG review).

By mid-2016, it is anticipated that an improved calibration of the PCB and mercury model will be completed based on data from about 41 calibration watersheds. Pending the outcomes of the 2016 work plan, STLS and the SPLWG will be consulted to agree upon and recommend a work plan for 2017. The goal of the additional work will be to get the PCB and Hg models sufficiently calibrated to meet the needs of BASMAA and other partners. The menu of options that will be considered to achieve this goal includes:

1. Recalibration of the hydrology model
2. Further (slight) improvements to the parameterization
3. Recalibration of the PCB and Hg models using data from 60+ watersheds (additional data collected by the RMP during WY 2016 and possibly data collected by the Santa Clara and San Mateo Stormwater programs using the RMP watershed characterization reconnaissance study methodology)
4. Response to user requests; for example in relation to effectiveness evaluation of stormwater BMPs
5. Completion of a user manual and full model documentation

Deliverables:

1. Technical report, including a summary of the model updates, results of the model calibration, and regional loads (Draft March 2017; Final June 2017) – Review by SPLWG and STLS.

<u>Trends Strategy ($100,000)</u>

With an increased focus on finding tributaries and sources with disproportionally high concentrations and loads of PCBs and Hg, and the transition from the pilot testing phase of BMP selection to focused implementation, it was recognized that a Strategy for monitoring trends was needed for stormwater concentrations and loads, connecting management effort on land with water quality improvements in the Bay.

During 2015, the RMP funded the first phase of developing the Small Tributaries Loading Strategy-Trends Strategy (STLS-T). Beginning in July 2015 and continuing through April 2016, a series of five STLS-T meetings occurred that resulted in the development of a series of interim products including a refined trends strategy workplan, a mission statement, the development of three key trends strategy management questions, a list of potential stormwater quality indicators, a number of conceptual models including a conceptual model of how those indicators relate to watershed scale, selection of the indicators and scales on which to focus

initial power analysis efforts, collation of available data, and development and implementation of a power analysis work plan. In April 2016 the first draft of the STLS-T strategy document was prepared ready for the STLS team review along with the results of the power analysis.

External peer review of the power analysis and strategy occurred in June 2016. We engaged with Bob Hirsch and Lori Sprague of the USGS who brought multiple decades of experience on the evaluation of storm water trends for the nations waters to the discussion. Their peer review over two days included in-depth discussion with the team and brought uniquely appropriate experience and qualifications. The primary recommendations from the peer reviewers included:

- Additional exploration of the existing dataset to determine if there are other explanatory factors or statistical models that would be helpful in designing a short and long-term trends strategy monitoring program.
- Additional data are needed from long term monitoring sites to augment the existing dataset. The primary recommendation was to "oversample" at one or two long-term monitoring sites.

A draft workplan to implement the recommendations of the peer reviewers was developed subsequent to the peer review meeting. The estimated budget for this workplan is $270,700 (see table below). The immediate available funding is $163,500, consisting of $63,500 of remaining RMP 2016 funds and $100,000 of RMP 2017 funds.

Available funding is less than the budget estimated for the workplan, so RMP staff will work with the STLS workgroup to review and prioritize workplan components. The workplan, as current designed, includes:

1. Additional data exploration (to be completed with RMP 2016 funds)
2. Design the WY 2017 trends monitoring plan (to be completed with RMP 2016 funds)
3. WY 17 trends monitoring, data management, data analysis, and reporting (Monitoring and initial data management to be done with RMP 2017 funds. Final data management and report is unfunded)
4. A follow-up peer-review meeting to discuss findings and next steps for the trends strategy (unfunded)
5. Develop a final trends sampling and analysis plan (unfunded)

Deliverable for RMP 2017 Funds:

1. Collection of stormwater samples (5 storm events plus remote sampler deployment at one site for 2 months) and initial data management (June 30, 2017)

<u>Small Tributary Loading Strategy Program Coordination ($30,000)</u>

The goal of the Small Tributaries Loadings Strategy (STLS) Program over the next few years is to continue to provide information to RMP Stakeholders and the public that directly supports the identification and management of PCBs and Hg sources, concentrations, loads, and the determination of trends in relation to management efforts and beneficial uses in San Francisco Bay. To support the Small Tributaries POC stormwater concentration and loading program, the outcome of this task will be to maintain monthly communication with BASMAA

program and Water Board representatives. This will be completed through regular check in phone calls, planning for and development of meeting agendas and materials, preparation of meeting summaries, and monitoring the agenda of and attendance at key external meetings.

Deliverables:

1. Monthly STLS meetings (January-December 2017)

Chemicals of Emerging Concern (CECs) ($284,835)

More than 100,000 chemicals have been registered or approved for commercial use in the U.S. For many of these chemicals, major information gaps limit the ability of scientists to assess their potential risks, and environmental monitoring of these chemicals is not required. Some of these chemicals have been classified as contaminants of emerging concern (CECs), often due to due to their high volume use, potential for toxicity in non-target species, and the increasing number of studies that report their occurrence in the environment. CECs can be broadly defined as synthetic or naturally occurring chemicals that are not regulated or commonly monitored in the environment but have the potential to enter the environment and cause adverse ecological or human health impacts.

The RMP has been investigating CECs since 2001 and developed a formal workgroup to address the issue in 2006. In 2013, the RMP finalized a three-element strategy to guide future work on CECs. The first element of the strategy is a continuation of targeted monitoring of CECs in San Francisco Bay via Special Studies, an RMP effort that has generated one of the world's most comprehensive datasets for CECs in an estuarine ecosystem. The relative risk of detected CECs is evaluated using a tiered risk and management action framework.

The second element of the RMP CEC strategy involves review of the scientific literature and other CEC aquatic monitoring programs as a means of identifying new CECs for which no Bay occurrence data yet exist. The third element of the strategy consists of non-targeted monitoring, including a) broadscan analyses of Bay biota samples, and b) development of bioassays to identify estrogenic effects, techniques designed to identify previously unknown CECs present in the Bay. The RMP's CEC program provides data critical to efforts of regulators working to manage the ever-growing variety of chemicals in commerce to ensure that they do not adversely impact human and environmental health.

<u>Imidacloprid in Ambient Bay Water ($40,110)</u>

Imidacloprid is a widely used neonicotinoid insecticide. Recent RMP-funded monitoring of 24-hour composite samples of influent and effluent from eight Bay wastewater treatment plants (WWTPs) found levels in discharged effluent that exceed an established aquatic toxicity threshold. Imidacloprid has been intermittently detected in Bay Area creeks at levels above this threshold. The proposed study would screen ambient water samples from San Francisco Bay to determine whether levels of imidacloprid, common imidacloprid degradates, and other neonicotinoid pesticides approved for use in California exceed aquatic toxicity thresholds. Findings are essential to appropriate classification of imidacloprid and other neonicotinoids within the RMP's tiered risk framework for contaminants of emerging concern (CECs), and may

influence ongoing efforts within the California Department of Pesticide Regulation aimed at reducing environmental contamination and ecological impacts of current use pesticides.

Deliverables:

1. Fact sheet on imidacloprid in ambient Bay water (Draft March 2018; Final June 2018) – Review by ECWG

Perfluorinated and Polyfluorinated Compounds in San Francisco Bay: Synthesis and Strategy ($56,300)

Perfluoroalkyl and polyfluoroalkyl substances (PFASs) are a class of fluorine-rich chemicals with extremely high persistence. Well-studied members of this family have been shown to be highly toxic, while others have received little to no testing. Concentrations of one PFAS, perfluorooctane sulfonate (PFOS), in Bay Area seals and bird eggs in 2004/2006 were some of the highest detected globally. As a result, PFOS has been identified as moderate concern (Tier III CEC) for San Francisco Bay. Recent monitoring suggests decreases in PFOS concentrations in seals and cormorants, likely as a result of changing use patterns that include a nationwide phaseout in 2002.

However, concentrations of other members of the PFAS family, the commonly monitored carboxylates, have remained relatively constant albeit it at substantially lower levels overall. Meanwhile, a number of "precursors," PFAS that degrade to the more persistent PFOS or PFOA, have been detected in sediments. Recent studies of Bay Area stormwater and wastewater suggest that a significant fraction of these precursors are of unknown chemical composition. All PFAS besides PFOS are considered possible concerns (Tier I CEC) for the Bay, as toxicity data are often incomplete or unavailable.

A comprehensive review of PFAS monitoring and toxicity data is needed to determine whether PFOS is the only member of the family to merit regular surveillance. (The RMP currently monitors for 13 perfluorinated chemicals including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonamide (PFOSA).) The purpose of this study is to synthesize the PFAS monitoring to date, to evaluate the classification of these compounds according to the RMP CEC tiers, and to develop a strategy for monitoring PFASs.

Deliverables:

1. Assessment of individual PFASs into tiers where sufficient information exists (Spring 2017)
2. PFAS Synthesis Report (Draft June 2017; Final September 2017) – Review by ECWG

Phosphate Flame Retardants in Ambient Bay Water ($47,125)

California's past implementation of unique flammability standards has resulted in decades of flame retardant additives in consumer goods. RMP-funded monitoring of ambient Bay water in 2013 revealed the presence of numerous phosphate flame retardants. Some South Bay samples exhibited levels of one particular flame retardant, triphenyl phosphate (TPhP), which approached an established marine aquatic toxicity threshold. New furniture testing data

also reveal key flame retardants in current use that have yet to be monitored. The proposed study would screen ambient water samples from San Francisco Bay to determine whether levels of TPhP or other widely used phosphate flame retardants commonly exceed aquatic toxicity thresholds. Findings are necessary to determine whether these chemicals have been appropriately classified as "possible concerns" (Tier I) within the RMP's Tiered Risk Framework for contaminants of emerging concern (CECs), and may influence ongoing efforts within state agencies aimed at reducing environmental contamination and ecological impacts of flame retardants.

Deliverables:

1. Report on phosphate flame retardants in ambient Bay water (Draft May 2018; Final August 2018) – Review by ECWG

Bisphenol Compounds in Ambient Bay Water ($50,000)

Bisphenols are a class of widely used endocrine-disrupting compounds, commonly found in polycarbonate plastics and epoxy resins and frequently detected in many environmental matrices. Bisphenol A (BPA) is a high-production volume compound, and use volumes of several BPA alternatives have increased in recent years. This study would screen ambient water samples from San Francisco Bay for 16 bisphenol compounds. The results of this initial screening will inform the classification of bisphenols within the RMP's tiered risk framework for contaminants of emerging concern (CECs).

Deliverables:

1. Report on bisphenol compounds in ambient Bay water (Draft September 2018; Final December 2018) – Review by ECWG

Triclosan in Small Fish ($41,300)

The RMP classification of the widely used antibacterial ingredient triclosan as an emerging contaminant of low concern (Tier II) for San Francisco Bay is based on a relatively small amount of data. A recent study of a West Coast estuary suggests monitoring in small fish may be a more sensitive indicator of impact; these data are lacking for San Francisco Bay. Characterization of triclosan in whole fish composites of juvenile salmon from the Puget Sound indicates levels of potential concern, despite low concentrations in estuary waters. Food web transfer is suspected of leading to the higher concentrations observed in small fish. The proposed study would screen Bay prey fish for triclosan and its metabolite, methyl triclosan, to determine whether levels may pose concerns. These data are essential to appropriately classifying triclosan within the RMP's tiered risk framework for contaminants of emerging concern (CECs), and may influence ongoing efforts among stakeholders and local and state agencies aimed at reducing environmental contamination and ecological impacts of this antibacterial agent.

Deliverables:

1. Report on triclosan in small fish (Draft April 2018; Final July 2018) – Review by ECWG

CEC Strategy Support ($50,000)

Increasing interest in emerging contaminants issues by the San Francisco Bay Regional Water Board, RMP stakeholders, and the general public is reflected in headline news as well as policy actions at local, state, and federal levels. The amount of effort needed to manage the RMP Emerging Contaminants Strategy has increased significantly in recent years. Core deliverables have been tracking new information regarding contaminant occurrence and toxicity and updating the RMP's Tiered Risk and Management Action Framework. New requests for information include assisting the Water Board with emerging contaminants action plans. Coordination of pro bono analyses by partners, such as BACWA and universities, is another rapidly expanding component of strategy implementation. A Bay-specific contaminant transport model will also be revised to incorporate better information on pathways, in response to a need for improved modeling capabilities identified by stakeholders and experts. Finally, an exploration of passive sampling capabilities has been identified as another near-term strategic goal.

Deliverables:
Activities will occur year-round through December 2017

1. Information gathering from a variety of sources throughout the year, including presentations at scientific conferences
2. Assist Water Board and other stakeholders with science summaries relating to policy including emerging contaminants action plans and comment letters regarding proposed actions of other agencies
3. Present an update of emerging contaminants strategy, ongoing or completed special and pro bono studies, and new studies to the Steering Committee
4. Review tiered monitoring and management risk framework, present findings to the Water Board
5. Provide brief update to the RMP CEC Strategy document, including revised tiered framework tables and multi-year plan
6. Update existing Bay contaminant transport model with improved stormwater and runoff information
7. Inform experts and stakeholders regarding the practical application of quantitative passive sampling methods in estuarine settings

PCBs ($40,000)

The goal of RMP PCB Strategy work over the next few years is to inform the review and possible revision of the PCB TMDL and the reissuance of the Municipal Regional Permit for Stormwater (MRP), both of which are tentatively scheduled to occur in 2020. The multi-year plan for studying PCBs in the margins has three components: conceptual model development, field studies to support/confirm the models, and initiation of trend monitoring.

Conceptual model development for a set of four representative priority margin units will provide a foundation for establishing an effective and efficient monitoring plan to track responses to load reductions and also help guide planning of management actions. The Emeryville Crescent was the first PMU to be studied in 2015-2016. The San Leandro Bay PMU

is second (2016-2017). Funding for the completion of the San Leandro Bay conceptual site model and first order mass budget will be provided as part of a Supplemental Environmental Project settlement. A technical report for this site will be completed in 2017.

The timing of preliminary field studies and trend monitoring will depend on the level of funding for the PCB Strategy from the RMP and external funding sources. Initial field work in San Leandro Bay began in 2016 using Supplemental Environmental Project funds, and it is anticipated that trend monitoring can begin in 2018.

Priority Margin Unit Conceptual Model Development for Steinberger Slough ($60,000)

The third PMU to be studied will be Steinberger Slough in San Carlos. Conceptual model development will follow the template established for the Emeryville Crescent PMU, with evaluations of loading, initial deposition, long-term fate, and bioaccumulation. While ideally the site model evaluations will conclude that it is possible to detect reduced concentrations in the Bay, it is also possible that the effort will conclude that this is not 3 feasible with a realistic effort given the relative magnitude of the reduced loading, the 4 reservoir of PCBs already in the PMU, and environmental variation.

Deliverable:

1. Conceptual Model Report for Steinberger Slough (Draft April 2017; Final August 2017) – Review by PCB strategy team

PCB Strategy Coordination and Technical Support ($10,000)

Funds for this task would enable SFEI to continue to consult with the PCB Workgroup and the Small Tributary Loadings Strategy Team regarding plans for the next iteration of the TMDL and RMP activities that can inform the TMDL. Funds would also support small-scale synthesis of information that is needed to support these discussions. The plan will include a multi-year schedule of budgets and deliverables aimed at providing a technical foundation for the next iteration of the TMDL.

Deliverable:

1. Updated PCB Multi-Year Plan, including schedule of budget and deliverables (June 2017) – Review by PCB strategy team
2. PCB Workgroup Meeting (June 2017)

Dioxin ($40,000)

San Francisco Bay was placed on the State of California's 303(d) list of impaired waters in 1998 as a result of elevated concentrations of dioxins and furans (commonly referred to as 'dioxin') in fish. RMP studies of contaminants in Bay sport fish conducted every three to five years since 1994 have found that dioxin concentrations are relatively unchanged over this time period and in some species, continue to greatly exceed screening values for human consumption. The available information for dioxin in the region was synthesized in a conceptual model/impairment assessment report in 2004 for the Clean Estuary Partnership. That report highlighted limited data and significant uncertainties and gaps in our understanding of spatial and temporal distributions of dioxin in Bay

waters and sediments, and in estimated loading rates via various pathways. The Dioxin Strategy Workgroup and Workplan were established shortly thereafter to identify and address the highest priority data needs. Data on dioxin in ambient open bay sediments has been roughly doubled since then, and the number of water locations characterized increased ten-fold, but the last samples collected in these matrices were in 2011. Dioxin in wetland sediment cores collected in 2006 has also been characterized, suggesting a drastic decrease from recent (post WWII) past concentrations, whereas open Bay cores show more uniform distributions, with concentrations in upper sections higher than in very deep pre-industrial sediments, but generally similar to current surface sediment concentrations. Additional information on loads from pathways such as atmospheric deposition and stormwater runoff in selected watersheds has also been collected.

Together the information collected to date can be synthesized to update our understanding of environmental distributions and processes of dioxin, with the aim of addressing the highest priority dioxin management questions (described below) and identifying remaining data needs or gaps/uncertainties.

This effort is needed in 2017 because the Water Board must resolve the 303(d) impairment listings and there is an associated NPDES interim permitting strategy that has allowed the Water Board and dischargers to avoid problematic limits in permits on the condition that studies are conducted to inform resolution of the listings. In addition, the dioxin dataset generated under the RMP Dioxin Strategy was primarily generated in 2009-2012 and is getting dated - synthesis and interpretation of these data now will avoid any real or perceived consequence of using a dated dataset and a need to resample.

<u>Dioxin Synthesis Report ($40,000)</u>

Additional data on dioxin concentrations and loads have been collected in various media since the last dioxin synthesis in 2004. This effort would formally report and interpret this new information and evaluate the needs or potential for additional data collection or management action for dioxins. This effort is needed in 2017 to resolve the 303(d) impairment listings and in support of NPDES permitting strategy. In addition, the dioxin dataset generated under the RMP Dioxin Strategy was primarily generated in 2009-2012 and is getting dated - synthesis and interpretation of these data now will avoid any real or perceived consequence of using a dated dataset and a need to resample.

The available (past and more recent data collected over the past decade) information will be applied to a simple one-box mass budget model to identify and prioritize remaining data gaps and/or conflicts with current conceptual models and expectations, in order to evaluate the needs for and possible designs of future monitoring and modeling efforts. Additionally, information on the other data collected (cores, spatial and temporal patterns in biota and ambient concentrations) will be examined to evaluate the likely trajectory of future sources and impairment. Optionally the data can also be applied to a simple bioaccumulation model (both previously applied to PCBs and other organics), which can help project MQ5 future scenarios, but is not needed for evaluating current trends.

Deliverable:

1. Dioxin synthesis report (Draft December 2017; Final March 2018)

Selenium ($47,000)

In April 2014 the RMP formed a Selenium Strategy Team to evaluate low-cost, near-term information needs that can be addressed by the Program in the next several years

In 2016, the State Water Resources Control Board approved a selenium TMDL for North San Francisco Bay. The TMDL established a target concentration of 11.3 µg/g dry weight in white sturgeon muscle tissue as the basis for evaluating impairment (Baginska 2015).

In June 2016 the USEPA published proposed aquatic life and aquatic-dependent wildlife criteria for selenium in the Bay and Delta (USEPA 2016). The proposal includes criteria for fish tissue (muscle and whole body), clam tissue, and water (dissolved and particulate phases).

Sturgeon Derby Monitoring ($42,000)

A third year of Sturgeon Derby monitoring will be conducted in collaboration with an annual sturgeon fishing derby held out of Martinez. This Derby offers the opportunity to collect a variety of tissue samples from fish caught for the competition. This will allow for comparison between selenium concentrations measured in tissues that are easy to obtain non-lethally (muscle plugs, fin rays) and those that are not, but may be of greater interest toxicologically (ovaries) or analyzed for microchemistry (otoliths, compared to fin rays).

This study will be performed in collaboration with USFWS, USGS, and the International Institute for Sustainable Development (IISD). SFEI staff will plan the study, perform sampling, manage the data, and write a brief technical report. USGS (Robin Stewart and her team) will analyze selenium and stable isotopes of C, N, and S in the plugs, and selenium in the ovaries. The stable isotopes will provide information on diet and habitat use by the sturgeon. Vince Palace and his team (IISD, University of Manitoba) will perform sampling and analysis of fin rays and otoliths. USFWS will assist with sample collection. The sampling will occur on Super Bowl weekend in 2017.

Tissues will be collected from up to fifteen female white sturgeon. Muscle plugs will be collected by SFEI and analyzed by USGS. Splits of the ovary samples will also be obtained from USFWS for analysis by USGS. Fin ray and otolith samples will be collected and processed by IISD for selenium microchemistry analysis. Otoliths samples will be used to help develop the analysis method for fin rays, which can be collected from sturgeon non-lethally during future monitoring efforts.

Deliverables:

1. Technical Report on Selenium in White Sturgeon from the 2017 Sturgeon Derby (Draft December 2017, Final February 2018) – Review by the Selenium Workgroup

Selenium Strategy Support ($10,000)

The Selenium Workgroup provides the forum for planning and coordinating projects for the improvement of information on selenium in the Bay. Funds for this task will enable SFEI to

continue to convene the Selenium Workgroup to allow discussions of plans for studies in support of implementation of the North Bay TMDL, to develop RMP workplans to support these efforts, and for synthesis of information that is needed to support these discussions. The workplan to be developed by June 2017 will include a multi-year schedule of budgets and deliverables. Clam and water monitoring after March 2017 would implement the new design.

Deliverables:

1. Selenium Multi-Year plan, including a multi-year schedule of budgets and deliverables for selenium monitoring in the Bay (June 2017)
2. Selenium Workgroup Meeting (June 2017)

Selenium Monitoring ($20,000)

Following up on discussions surrounding the North Bay TMDL, the San Francisco Water Board asked the Selenium Workgroup to develop a robust monitoring design for the North Bay. The goal is to identify leading indicators of change to allow prompt management response to signs of increasing impairment. The Workgroup convened a technical workshop on this topic on July 27, 2016. At this workshop, participants reached a consensus that monitoring of sturgeon, clams, and water are all needed to answer management questions. Funding the continued monitoring of clams in Suisun Bay from October 2016 to March 2017 was identified as an urgent and immediate priority. Alternative study options include (1) analyzing archived muscle plugs from 2015 or (2) supporting compilation and analysis of sturgeon telemetry data.

Deliverables
TBD by Selenium Workgroup

Exposure and Effects ($55,000)

Estrogen receptor *in vitro* assay linkage studies ($45,000)

The RMP has funded a study to develop quantitative linkages between in vitro bioanalytical assays and higher order in vivo endpoints that point to population level effects in estuarine fish. The objective of this effort is to develop a cost-effective, high throughput tool that will assist in the identification of chemicals of emerging concern that are adversely affecting biota. The current proposal would support addressing two objectives: (1) repeating the in vivo portion of the previous linkage study with tighter concentrations around the likely EC-50 for in vivo responses, which will help narrow the comparison between in vitro and in vivo endpoints, and (2) testing water and sediment from six locations in San Francisco Bay for estrogenic equivalencies as a pilot test for this bioanalytical tool.

Deliverable:

1. Estrogen Receptor Assay Technical Report (December 2017) – Review by EEWG and ECWG

Strategy for Benthos and Sediment Toxicity Monitoring by the RMP ($15,000)

Monitoring for benthic invertebrates and sediment toxicity has been part of the RMP Status & Trends Program for decades. From 2009-2016, a number of special studies have been completed on benthic assessment tools and the causes of moderate sediment toxicity in the Bay. No additional studies are planned. In 2018, the RMP is scheduled to collect the next round of benthic invertebrate and sediment toxicity data. This study will support the development of a short strategy document outlining what has been learned over the past 7 years of special studies and how the RMP should proceed in the future with benthic monitoring.

Strategy Document Outline

1. Upcoming management decisions, management utility of the data
    a. Sediment Quality Objectives
    b. Benthic grazer abundance for NMS modeling and studies
    c. Baseline for biological invasions, "step changes" in Bay ecology
    d. Possible endpoint for effects of PAHs in sediment

2. Synthesis of RMP studies on benthos and sediment toxicity methods
    a. Summary of previous work (RMP and others)
    b. Highlight resolved and unresolved issues of management relevance

3. Summarize alternatives to the RMP methods for benthic monitoring
    a. Benthic cameras
    b. In-situ assays
4. Multi-Year Plan for benthos and sediment toxicity monitoring by the RMP
    a. S&T Monitoring Schedule (Note: the EEWG recommends collecting benthos and sediment toxicity data in 2018 as planned. The strategy would guide how that data should be collected and how they should be interpreted.)
    b. Special Studies

Expected document length: 10-20 pages

Deliverables:

1. Stakeholder engagement on management relevance: 1-2 calls with interested stakeholders and discussion at the TRC and EEWG meetings (by June 15, 2017)
2. White paper with Multi-Year Plan for Benthic Sampling (Draft March 2017; Final September 2017) – Review by EEWG

Sediment ($50,000)

Sediment Monitoring Strategy ($50,000)

SFEP, SFEI, and other partners received funding from EPA for a Water Quality Improvement Fund (WQIF) grant. In broad terms, the proposed project filld in critical data gaps needed to improve sediment management that supports baylands resilience. One critical task of the project is developing a sediment strategy for the San Francisco Bay-watershed system. On May 18, 2016, the Steering Committee approved $50,000 of matching funds to augment the WQIF grant. The deliverable for the funds will be a sediment monitoring strategy.

Deliverables:

1. Sediment Monitoring Strategy (Draft 1/1/19; Final 6/30/19) – Review by technical advisory committee for WQIF grant

The strategy will address monitoring that can be implemented to inform management decisions about sediment supply to the baylands (including which areas may need supplemental sediment placement), fluxes of chemical contaminants attached to fine sediments, and water clarity in the Bay.

Table 6: Bay RMP 2017 Special Studies Budget by Subtask.

Task	Subtask	Direct Cost	Labor	Subcontract	Grand Total
7. Special Studies	Dioxin Synthesis		$40,000		$40,000
	EC Bisphenol Water Monitoring[1]	$2,000	$35,500	$12,500	$50,000
	EC Imidacloprid Water Monitoring	$1,350	$25,010	$13,750	$40,110
	EC PFAS Synthesis[1]		$54,800	$1,500	$56,300
	EC Phosphate Flame Retardant Water Monitoring[1]	$2,000	$30,125	$15,000	$47,125
	EC Strategy Support		$50,000		$50,000
	EC Triclosan Fish Monitoring[1]	$2,700	$29,800	$8,800	$41,300
	EE Benthos Toxicity Monitoring Strategy		$10,000		$10,000
	EE Bioanalytical Tools			$45,000	$45,000
	Nutrient Moored Sensor Monitoring	$0	$220,000	$0	$220,000
	Nutrient Ship-Based Monitoring		$153,000	$0	$153,000
	PCB Steinberger Slough Conceptual Model		$60,000		$60,000
	PCB Strategy Support		$10,000		$10,000
	Sediment Strategy Development		$50,000		$50,000
	Selenium 2017 Derby Monitoring	$850	$26,150	$15,000	$42,000
	Selenium Monitoring		$20,000		$20,000
	Selenium Strategy Support		$10,000		$10,000
	STLS Regional Watershed Model		$40,000		$40,000
	STLS Strategy Coordination		$30,000		$30,000
	STLS Trends Strategy		$100,000	$0	$100,000
	STLS Wet Weather Characterization	$0	$200,000	$0	$200,000
Grand Total		$8,900	$1,194,385	$111,550	$1,314,835

1 – These studies will be supported with Alternative Monitoring Requirement funds.

Appendix A: Bay RMP 2017 Programmatic Task Descriptions, Budget Justifications, and Deliverables.

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
1. Program Management	A. Program Planning	Labor	$40,000		Preparing annual workplans and budgets (Detailed Workplan, Multi-Year Plan) plus other program planning activities.	2017 Multi-Year Plan (draft in October '16, final in January '17), 2016 Detailed Workplan (draft in October '16, final in January '17)
1. Program Management	B. Contract and Financial Management	Labor	$169,000		Tracking expenditures versus budget, accounting, updating planned hours, working with auditors, preparing financial updates to RMP SC, developing contracts, overseeing contracts, invoicing stakeholders, updating the MOU between SFEI-ASC and the Water Board as needed.	Quarterly financial updates to SC. Quarterly updates to planned budget in accounting software.
1. Program Management	B. Contract and Financial Management	Direct Cost	$1,000	Bank activity charges		
1. Program Management	C. Technical Oversight	Labor	$50,000		Review of work products by Lead Scientist, Program Manager, and Senior Scientists to ensure the quality of RMP deliverables.	Improved quality work products
1. Program Management	D. Internal Coordination	Labor	$80,000		Workflow planning, tracking deliverables, and holding staff meetings.	RMP Deliverables Tracking System and Stoplight Reports (quarterly at SC meetings)

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
1. Program Management	E. External Coordination	Labor	$40,000		Participation in meetings with external partners to coordinate programs (e.g., linking RMP monitoring with IEP, DWR, UC Davis, Bay Area universities, South Bay Salt Ponds Restoration, SWAMP, SCCWRP, serving as liaison to the Delta RMP and other RMPs)	Program efficiencies through coordination with partners.
1. Program Management	F. Administration	Labor	$9,000		Office management assistance (e.g., ordering supplies, arranging travel).	
1. Program Management	F. Administration	Direct Cost	$500	Project-specific mailings		
1. Program Management	F. Administration	Direct Cost	$500	Courier expenses for documents. Charges for shipping samples are not included in this line. They are included in S&T monitoring budgets		
1. Program Management	F. Administration	Direct Cost	$2,000	Specialized technical and program management software. Includes $100 for SmartSheet license		
1. Program Management	F. Administration	Direct Cost	$2,000	Subscriptions to access online scientific articles. Technical books or journals. Downloads of journal articles.		

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
2. Governance	A. SC meetings	Labor	$48,000		Preparing agendas, agenda packages, participating in meetings, writing meeting summaries, action item follow-up, reviewing minutes from past meetings. Pre-meeting with Chair and Co-Chair.	4 SC meetings
2. Governance	A. SC meetings	Direct Cost	$2,000	Catering for Steering Committee meetings. Typical catering cost is $400 per meeting. 4 meetings per year.		
2. Governance	B. TRC meetings	Labor	$43,000		Preparing agendas, agenda packages, participating in meetings, writing meeting summaries, action item follow-up, reviewing minutes from past meetings.	4 TRC meetings
2. Governance	B. TRC meetings	Direct Cost	$2,000	Catering for Technical Review Committee meetings. Typical catering cost is $400 per meeting. 4 meetings per year.		

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
2. Governance	C. WG meetings	Labor	$112,000		Preparing proposals for special studies, agendas, agenda packages, participating in meetings, writing meeting summaries, action item follow-up, reviewing past meeting minutes.	7 Workgroup meetings - ECWG, SPLWG, EEWG, PCB, Dioxin, Selenium, Microplastic Participation in Sediment Strategy Team meetings.
2. Governance	C. WG meetings	Direct Cost	$3,000	Catering for Workgroup meetings. Typical catering cost is $300 per meeting. 7 meetings per year.		
2. Governance	D. External Science Advisors	Direct Cost	$40,000	Honoraria for external advisors to RMP Workgroups. Assumes $2k honoraria for 20 advisors		
2. Governance	D. External Science Advisors	Direct Cost	$20,000	Travel expenses for external advisors		
3. QA and Data Services	A. Quality Assurance System	Labor	$30,000		Updating the Quality Assurance Project Plan, writing a summary QA Report, conducting interlaboratory comparison tests, and researching analytical methods. Maintaining the SFEI laboratory SOP file system.	(1) Annual QAPP update (2) Prepare QA Summary Reports for birds, bivalves, margins and water RMP projects (3) Host QA Meeting with RMP labs at the end of 2017 (4) Respond to QA Officer requests
3. QA and Data Services	A. Quality Assurance System	Subcontract	$10,000	Funds for inter-laboratory comparison studies		

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
3.QA and Data Services	B. Online Data Access: CD3	Labor	$65,000		Adding enhancements and updates to web-based data access tool CD3.	(1) Add ability to filter by user-defined threshhold; (2) Add Station Names to pop-up boxes; (3) Migrate application to OpenLayers3 to provide better quality maps; (4) Tool maintenance and performance upgrades.
3. QA and Data Services	C. Database Maintenance	Labor	$50,000		Incorporating updates and corrections to data as needed, including re-analyzed results and updates implemented by CEDEN/SWAMP.	(1) upload priority CEC datasetsas requested by Dr Becky Sutton (2) Upload PFC datasets (3) Upload 1993-2014 CTD data (4) Update database to implement changes made by CEDEN for standard vocabulary codes, business rules and database structure (5) Update records and address issues as identified by internal staff (6) Perform scheduled database maintenance.
3. QA and Data Services	D. Updates to SOPs and Templates	Labor	$30,000		Developing and enhancing software tools and processes such as EDD templates and writing and maintaining internal SOPs to increase efficiency of data management tasks	(1) Develop data submittal portal (2) Modify templates, queries and SOPs as needed (3) Begin discussion on how to manage sums (4) Discuss the roadmap for updating the CEDEN data checker with SWRCB staff

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
4. Annual Reporting	A. Pulse Report	Labor	$70,000	The 2015 Pulse cost $120k ($60k for labor, $40k for consultants, and $20k for printing). The total cost proposed for 2017 is $135k. The increase is due to time needed to update kriging for "Pulse maps' and 25th anniversary themes.	Preparing technical content (text, analyses, graphics) and web presence. Managing contractors for design, editorial content, and printing/mailing.	2017 Pulse Report (September)
4. Annual Reporting	A. Pulse Report	Direct Cost	$30,000	Printing and mailing costs for hard-copy report. The print run will be 1500 copies.		
4. Annual Reporting	A. Pulse Report	Subcontract	$35,000	Subcontracts for graphic design.		
4. Annual Reporting	B. Annual Meeting	Labor	$50,000	The 2015 RMP Annual Meeting at SOTEC cost $75k. The proposed cost for the 2017 meeting is $81.5k. The increased cost is due to 25th anniversary themes and an increased contribution to the SOTEC effort. It would be less expensive to hold a stand-alone RMP meeting. The 2016 RMP Meeting cost $60,000.	Developing the meeting agenda, managing logistics, advertising about the meeting, managing attendee registration, preparing presentations, staffing the meeting. Direct costs for Save the Date mailings, venue, and catering. Travel funds for outside speakers.	2017 Annual Meeting (September)
4. Annual Reporting	B. Annual Meeting	Direct Cost	$1,000	Save the Date cards printed and mailed to RMP distribution list (900 people). Costs include printing and mailing.		

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
4. Annual Reporting	B. Annual Meeting	Direct Cost	$22,500	Venue rental and catering for RMP Annual Meeting or contribution to SOE Meeting		
4. Annual Reporting	B. Annual Meeting	Subcontract	$5,000	Design consultant		
4. Annual Reporting	B. Annual Meeting	Direct Cost	$3,000	Travel to RMP Annual Meeting for invited speakers.		
5. Communications	A. Communications Plan Implementation	Labor	$32,000	Labor cost estimate includes $20k for effort on 25th Anniversary.	Coordinating the distribution of RMP information to stakeholders, natural resource managers, and the public through multiple media channels (e.g., Estuary News, website, publications, email newsletters, fact sheets, social media, etc.). Coordinating and reviewing content for the newsletter.	4 issues of Estuary News with RMP content (quarterly). 4 RMP eUpdate Newsletters (quarterly).
5. Communications	A. Communications Plan Implementation	Direct Cost	$15,000	Contribution to SFEP to Estuary News		
5. Communications	A. Communications Plan Implementation	Direct Cost	$3,000	Subcontract for Estuary News content		

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
5. Communications	B. Stakeholder Engagement	Labor	$28,000		Preparing for and attending RMP stakeholder meetings (e.g., BACWA, BASMAA, LTMS, WSPA, RB2) as well as communicating directly with stakeholder representatives.	RMP presentations at BACWA, BASMAA, LTMS, BPC, WSPA, and RB2 Meetings.
5. Communications	C. Responses to Information Requests	Labor	$12,000		Responding to inquiries for RMP data and reports, including press calls.	Timing delivery of RMP information to stakeholders. Timely responses to press calls.
5. Communications	D. Fact Sheets and Outreach Products	Labor	$7,500		Producing technical content and design for fact sheets on high profile RMP topics	1-2 Fact Sheet (content TBD).
5. Communications	D. Fact Sheets and Outreach Products	Direct Cost	$500	Printing costs		
5. Communications	D. Fact Sheets and Outreach Products	Subcontract	$2,000	Subcontractor for graphic design		
5. Communications	E. Presentations at Conferences and Meetings	Labor	$30,000	Assumes partial coverage for RMP posters or presentations at up to 6 conferences or local meetings.	Preparation for and participation in workshops and conferences for SWAMP, NorCal SETAC, ACS, and other professional organizations; as well as presentations at local meetings. Direct costs for travel and conference registration. Subcontracts for poster design and layout.	Presentation of RMP data at up to 6 conferences or local meetings (December).

Task	Subtask	Expense Type	Budget Final	Budget Estimate Notes	Description	Deliverables
5. Communications	E. Presentations at Conferences and Meetings	Subcontract	$5,000	Subcontractor for graphic design		Up to 6 posters with RMP data for conferences.
5. Communications	E. Presentations at Conferences and Meetings	Direct Cost	$10,000	Travel and registration costs for RMP staff to attend conferences, workshops, and local meetings. Assuming 4 conferences at $2,000 per conference plus $2,000 for travel costs for local meetings.		
5. Communications	G. RMP Website Maintenance	Labor	$20,000		Updating the RMP website with new reports and items. Funds for online data access tools (e.g., CD3) are in the Data Management budget.	Updates to website with new reports and content (at least quarterly).

DIOXIN SYNTHESIS REPORT

Donald Yee, Jay Davis, SFEI, Richmond, CA

ESTIMATED COST: $40,000
OVERSIGHT GROUP: Dioxin Workgroup

Proposed Deliverables And Timeline

Deliverable	Due Date
Task 1. Simple numerical models	Mar 2017
Task 2. Draft report	Oct 2017
Task 3. Final report	Dec 2017

Summary

Additional data on dioxin concentrations and loads have been collected in various media since the last dioxin synthesis in 2004. This effort would formally report and interpret this new information and evaluate the needs or potential for additional data collection or management action for dioxins. This effort is needed in 2017 to resolve the 303(d) impairment listings and in support of NPDES permitting strategy. In addition, the dioxin dataset generated under the RMP Dioxin Strategy was primarily generated in 2009-2012 and is getting dated - synthesis and interpretation of these data now will avoid any real or perceived consequence of using a dated dataset and a need to resample.

Background

San Francisco Bay was placed on the State of California's 303(d) list of impaired waters in 1998 as a result of elevated concentrations of dioxins and furans (commonly referred to as 'dioxin') in fish. RMP studies of contaminants in Bay sport fish conducted every three to five years since 1994 have found that dioxin concentrations are relatively unchanged over this time period and in some species, continue to greatly exceed screening values for human consumption. The available information for dioxin in the region was synthesized in a conceptual model/impairment assessment report in 2004 for the Clean Estuary Partnership. That report highlighted limited data and significant uncertainties and gaps in our understanding of spatial and temporal distributions of dioxin in Bay waters and sediments, and in estimated loading rates via various pathways. The Dioxin Strategy Workgroup and Workplan were established shortly thereafter to identify and address the highest priority data needs. Data on dioxin in ambient open bay sediments has been roughly doubled since then, and the number of water locations characterized increased ten-fold, but the last samples collected in these matrices were in 2011. Dioxin in wetland sediment cores collected in 2006 has also been characterized, suggesting a drastic decrease from recent (post WWII) past concentrations, whereas open Bay cores show more uniform distributions, with concentrations in upper sections higher than in very deep pre-industrial sediments, but generally similar to current surface sediment concentrations. Additional information on loads from pathways such as atmospheric deposition and stormwater runoff in selected watersheds has also been collected.

Together the information collected to date can be synthesized to update our understanding of environmental distributions and processes of dioxin, with the aim of addressing the highest priority

dioxin management questions (described below) and identifying remaining data needs or gaps/uncertainties.

This effort is needed in 2017 because the Water Board must resolve the 303(d) impairment listings and there is an associated NPDES interim permitting strategy that has allowed the Water Board and dischargers to avoid problematic limits in permits on the condition that studies are conducted to inform resolution of the listings. In addition, the dioxin dataset generated under the RMP Dioxin Strategy was primarily generated in 2009-2012 and is getting dated - synthesis and interpretation of these data now will avoid any real or perceived consequence of using a dated dataset and a need to resample.

Applicable RMP Objectives and Management Questions

The work to be synthesized in the report addresses the following RMP Objectives and Management Questions in the Dioxin Strategy, with the focus on questions identified by the Workgroup as most directly linked to possible management actions underlined:

MQ.1 Are chemical concentrations in the Bay at levels of potential concern and are associated impacts likely?

- Are the beneficial uses of San Francisco Bay impaired by dioxins?

MQ.2 What are the concentrations and masses of contaminants in the Bay and its segments?

- What is the spatial pattern of dioxin impairment?
- What is the dioxin reservoir in Bay sediments and water?

MQ.3 What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Bay?

- What is the relative contribution of each loading pathway as a source of dioxin impairment in the Bay?

MQ.4 Have the concentrations, masses, and associated impacts of contaminants in the Bay increased or decreased?

- Have dioxin loadings/concentrations changed over time?

MQ.5 What are the projected concentrations, masses, and associated impacts of contaminants in the Bay?

- What future impairment is predicted for dioxins in the Bay?

Approach

The available (past and more recent data collected over the past decade) information will be applied to a simple one-box mass budget model to identify and prioritize remaining data gaps and/or conflicts with current conceptual models and expectations, in order to evaluate the needs for and possible designs of future monitoring and modeling efforts. Additionally, information on the other data collected (cores, spatial and temporal patterns in biota and ambient concentrations) will be examined to evaluate the likely trajectory of future sources and impairment. Optionally the data can

also be applied to a simple bioaccumulation model (both previously applied to PCBs and other organics), which can help project MQ5 future scenarios, but is not needed for evaluating current trends.

Reporting

Results of applied models and associated monitoring data in various matrices for the Bay will be reported as a RMP Technical Report, to be delivered in the fourth quarter of 2017.

Proposed Budget

Estimated costs for each of the elements are presented. Even if data are not applied to a numerical mass budget model, information will still need to be considered in the context of conceptual models of contaminant processes and fate, so costs for the first task can be reduced (roughly halved), but not eliminated.

Task	**Estimated Cost**
1. Application of data to mass budget and simple bioaccumulation model	$20,000
2. Draft report	$15,000
3. Final report	$5,000
Total	**$40,000**

Special Study Proposal: Bisphenol Compounds in Ambient Bay Water

Summary: Bisphenols are a class of widely used endocrine-disrupting compounds, commonly found in polycarbonate plastics and epoxy resins and frequently detected in many environmental matrices. Bisphenol A (BPA) is a high-production volume compound, and use volumes of several BPA alternatives have increased in recent years. This study would screen ambient water samples from San Francisco Bay for 16 bisphenol compounds. The results of this initial screening will inform the classification of bisphenols within the RMP's tiered risk framework for contaminants of emerging concern (CECs).

Estimated Cost: $50,000

Oversight Group: ECWG

Proposed by: Jennifer Sun and Rebecca Sutton (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	***Due Date***
Task 1. Project Management (manage subcontracts, track budgets)	2017-2018
Task 2. Develop detailed sampling plan	Spring 2017
Task 3. Field sampling – ambient Bay water	Summer 2017
Task 4. Lab analysis	Fall-Winter 2017
Task 5. QA/QC and data management	Spring 2018
Task 6. Draft technical report	9/30/18
Task 7. Final technical report	12/31/18

Background

Bisphenols are a class of widely produced endocrine-disrupting chemicals that are used in the manufacturing of polycarbonate plastics and epoxy resins, as well as various other products, including as developers applied on thermal receipt paper. Bisphenol A (BPA), the most widely used and studied bisphenol, is one of the highest production volume chemicals in the world (4.6 million tons in 2012), and can be found in products ranging from automotive and electrical equipment, linings for food containers and drinking water pipes, and thermal paper used in receipts such as those used at ATMs, gas stations, restaurants, and grocery stores (MRC, 2014; EPA Action Plan, 2010).

Leading up to California state and federal bans on BPA in certain feeding containers for children and babies in the early 2010s, several major manufacturers began replacing BPA in their products with alternative compounds – most commonly, Bisphenol S (BPS) and bisphenol F (BPF), two of the most structurally similar bisphenols to BPA. Measured concentrations of BPS and BPF in human urine in the United States appear to reflect that use volumes of these alternative bisphenol compounds have been increasing in recent years (Ye et al., 2015).

At the same time, concentrations of BPA use in other materials remain high. Recent studies have found high concentrations of both BPA and BPS (for example, 14 mg of BPA on a 3.125 x 12 in receipt) on thermal receipt papers, on which these compounds are used as developers (Apfelbacher, 2014). Bisphenols applied to the surface of the receipt paper are not bound to a polymer, and thus are very transferrable both to humans and the environment. Studies have shown that concentrations of BPA can be up to 10 times higher in the urine of humans that have handled BPA-coated receipt paper for just four minutes (Hehn, 2015; Hormann et al., 2014).

These compounds have been linked to a variety of potential negative health impacts in humans and wildlife, including estrogenic and genotoxic effects (Rosenmai et al., 2011; OEHHA, 2012; Lee et al. 2013). In 2011, a new aquatic hazard assessment lowered an aquatic health threshold (Predicted No Effects Concentration (PNEC)) for BPA from 100 ug/L to 0.06 ug/L, based on an assessment of 61 studies evaluating the ecotoxicological endpoints of survival, growth, development and reproduction in freshwater and marine organisms (Wright-Walters et al., 2011). This suggests that many previous measurements of BPA with method detection limits (MDLs) higher than 0.06 ug/L may no longer be adequate for assessing the risk of BPA toxicity.

Empirical data on the toxicity and environmental fate of most alternative bisphenol compounds are scarce, but a 2015 USEPA review of BPA and 4 bisphenol alternatives (BPS, BPF, BPC, BPAP, BPPH) in thermal paper gave the alternatives "Moderate" or "High" hazard designations for most human health or aquatic toxicity endpoints, and identified no clearly safer alternatives to BPA (US EPA, 2015). A review conducted by Biomonitoring California (a joint program of the California Department of Public Health, Department of Toxic Substancse Control, and Office of Environmental Health Hazard Assessment) in 2012 also predicted that many of the alternatives such as Bisphenol A-diglycidyl ether (BA-DGE), Bisphenol AF (BPAF), Bisphenol AP (BPAP), Bisphenol B (BPB), Bisphenol C (BPC), Bisphenol F (BPF), and Bisphenol PH (BPPH) were likely to be toxic or very toxic to aquatic organisms, according to US EPA criteria (OEHHA, 2012).

Although BPA and several of its alternatives photo- and biodegrade relatively quickly under aerobic conditions, degradation for BPA, BPE, BPB, and BPS has been shown in laboratory experiments to be slow under anaerobic conditions, such as in anoxic estuarine sediments (Voordeckers et al., 2002; Ike et al., 2006). Biodegradation of BPS in particular has also been shown in laboratory experiments to be slow in both artificial and field-collected seawater (no degradation detected in 30 days; Danzl et al., 2009). Several bisphenol alternatives evaluated by the US EPA's Persistent, Bioaccumulative and Toxic (PBT) Profiler are predicted to be "persistent" or "very persistent" in water (BA-DGE and BPAF) and sediment (BA-DGE, BPAF, BPAP, BPB, BPC, BPF, BPAP, BPS) according to US EPA criteria (OEHHA, 2012). Furthermore, regardless of degradation potential, the high production volume of these compounds suggests a constant source entering the environment, which may render even those compounds that degrade quickly a potential exposure concern for wildlife. Bisphenols are regularly detected in estuarine and marine waters, wastewater effluent and sludge, stormwater runoff, wildlife, sediment, freshwater bodies, groundwater, rainfall, air, and other environmental matrices (Flint et al., 2012; Huang et al., 2011; Cargheni, 2015), as well as human urine samples (BPA, BPS, BPF, and BPAF) (Ye et al., 2015; Liao et al., 2012).

The RMP had previously analyzed ambient Bay water samples for BPA (but no alternatives) as part of a broader pharmaceuticals scan in 2010 (Klosterhaus et al., 2013), but the detection limit used in

the analysis was 2.5 ug/L, well above the more recently established 0.06 ug/L PNEC (Wright-Walters et al., 2011), because the method is not specifically optimized for BPA detection. As a result, bisphenols are currently classified as an emerging contaminant of Possible Concern (Tier 1) in the RMP's CEC risk and management action framework, due to a lack of monitoring information (Sutton and Sedlak 2015). In 2014, the Emerging Contaminants Workgroup suggested that staff prepare a proposal to monitor for a broader panel of analytes that would include all possible bisphenols in production and amenable to analysis.

RMP has been working with laboratories to support better method detection limits for bisphenols and we believed that the methods are now robust enough to conduct a study to evaluate this class of compounds in the Bay. Most recently, the RMP participated in a pro-bono collaboration with Dr. Da Chen at Southern Illinois University to support development of a method for analyzing for a suite of bisphenol compounds in ambient Bay water samples. Method development is now complete, and provides the broadest assessment of bisphenols available.

This proposal outlines a study to monitor for BPA and 15 alternative bisphenol compounds in ambient Bay water. The results from this study will help indicate the level of risk posed by BPA and alternative bisphenols to wildlife in the Bay.

Study Objectives and Applicable RMP Management Questions

This study will provide data essential to determining the placement of bisphenols in the RMP's tiered risk framework, which guides monitoring and management actions on emerging contaminants in San Francisco Bay (Sutton et al. 2013; Sutton and Sedlak 2015). While limited monitoring data on bisphenols in the Bay is available, use volumes suggest that bisphenols are ubiquitous in the environment. Management questions to be addressed by this study are the same as those of the overall RMP program, as shown in Table 1.

Table 1. Study objectives and questions relevant to RMP management questions.

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	Compare measured concentrations to toxicity thresholds.	Do findings suggest BPA and other bisphenols should be classified as moderate concern, low concern, or possible concern emerging contaminant within the RMP's tiered risk framework? Do the data indicate a need for management actions?
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?	Compare levels in different embayments.	Do specific embayments or regions appear to have greater levels of contamination?
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?		
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.1. What are the effects of management actions on concentrations and mass?		
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?		

In addition to addressing questions 1 and 2, the study will address the established emerging contaminants priority question: What emerging contaminants have the potential to adversely impact beneficial uses of the Bay? BPA is currently listed as a contaminant of possible concern (Tier 1) in RMP's tiered risk and management action framework due to a lack of information; findings will allow the ranking of this chemical to be reevaluated.

Approach

Ambient Bay Water Sampling

BPA and other bisphenols have been detected in ambient estuary water from urbanized estuaries around the world, where they may pose a threat to both human and wildlife health. BPA

concentrations in Puget Sound, a comparably urbanized estuarine system relative to the San Francisco Bay, were found to range from 0.0028 – 0.0043 ug/L. At these concentrations, BPA was shown to accumulate up to concentrations of 0.041 ug/g (wet weight) in salmon and 0.0045 ug/g in sculpin that use the estuary (Meador et al., 2015). Ambient water concentrations measured in the Yangtze River Estuary and East China Sea ranged from 0.00098 to 0.043 ug/L during the wet season (Shi et al., 2013). These results suggest that while ambient Bay water concentrations would be expected to be low relative to source concentrations, estuary water BPA concentrations have been measured on the same order of magnitude as the 0.06 ug/L BPA PNEC in other urban estuary systems, and it is possible that such levels of bisphenol pollution are present in the Bay as well.

Bay water sample collection will take place in the summer of 2017 as part of the RMP's regular Status and Trends water monitoring cruise. Grab samples of ambient Bay water (4 L, amber glass, 3 day hold time) will be collected at 22 Bay sites, including the 5 historical fixed sites and 17 random sites (three or four samples in each segment of the Bay). One field replicate and one field blank will also be collected.

Analytical Methods

BPA is moderately hydrophilic and bioaccumulative (log Kow = 3.4). In measurements of surface water and wastewater samples, BPA has been predominantly measured in the dissolved water fraction compared to particulates (Kalmykova et al. 2013). However, other BPA alternatives are predicted to more strongly adhere to sediments (log Kows: BPAF 4.47; BPB 4.13; BPAP 4.86; BPC 4.73) (OEHHA 2012). Thus, water samples will be collected and analyzed in total phase, including separate analyses for the dissolved and particulate fractions. Findings from this study may suggest whether or not future monitoring of sediment is warranted.

Total water samples will be analyzed by Dr. Da Chen of Southern Illinois University using a highly sensitive liquid chromatography–electrospray ionization(-)-triple quadrupole mass spectrometry (LC–ESI(-)-QQQ-MS/MS) based analysis method. This method will include analysis of bisphenol A, as well as suite of alternative bisphenol compounds, including bisphenols B, C, AF, AP, BP, M, E, P, F, PH, Z, G, TMC, and C-dichloride, as well as bisphenol A diglycidyl ether (BPA-DGE). Limits of detection are typically in the range of 0.1-0.5 ng/L, except for BPA-DGE (0.8 ng/L) and BPA-dichloride (1.0 ng/L). Per sample analytical costs are estimated to be $500.

Reporting

The following budget represents estimated costs for this proposed special study (Table 2). Efforts and costs can be scaled back by reducing the number of sites or matrices sampled.

Table 2. Proposed Budget

Task	Estimated Cost
Labor*	
Project Planning	$2,000
Field Work – 2017 Status & Trends Water Cruise	$0
Data Management	$2,000
Analysis & Reporting	$31,500
Subtotal	**$35,500**
Subcontracts	
Southern Illinois University – 25 samples @ $500/sample	$12,500
Subtotal	**$12,500**
Direct Costs	
Equipment	$100
Shipping	$1.700
Travel	$200
Subtotal	**$2,000**
Grand Total	**$50,000**

Budget Justification

Field Costs
Field costs are minimized through sample collection during the RMP's 2017 Status and Trends water sampling cruise.

Laboratory Costs
Analytical costs per sample are estimated to be $500. For 24 samples, including one field replicate and one field blank, the total analytical cost will be $12,000.

Data Management Costs
To minimize data management costs, data will undergo QA/QC by the laboratory and project PI, but will not formatted and uploaded to CEDEN. If bisphenol compounds are incorporated into standard RMP sampling events, this data may be added to CEDEN at a later date.

Reporting

Results will be provided to the RMP committees in a technical report, which will be distributed for internal RMP review only prior to the publication of a peer-reviewed journal manuscript. A draft of the report will be provided for review by 9/30/18. Comments will be incorporated into the final report by 12/13/18.

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Special Study Proposal: Imidacloprid in Ambient Bay Water

Summary: Imidacloprid is a widely used neonicotinoid insecticide. Recent RMP-funded monitoring of 24-hour composite samples of influent and effluent from eight Bay wastewater treatment plants (WWTPs) found levels in discharged effluent that exceed an established aquatic toxicity threshold. Imidacloprid has been intermittently detected in Bay Area creeks at levels above this threshold. The proposed study would screen ambient water samples from San Francisco Bay to determine whether levels of imidacloprid, common imidacloprid degradates, and other neonicotinoid pesticides approved for use in California exceed aquatic toxicity thresholds. Findings are essential to appropriate classification of imidacloprid and other neonicotinoids within the RMP's tiered risk framework for contaminants of emerging concern (CECs), and may influence ongoing efforts within the California Department of Pesticide Regulation aimed at reducing environmental contamination and ecological impacts of current use pesticides.

Estimated Cost: $40,110

Oversight Group: ECWG

Proposed by: Rebecca Sutton and Jennifer Sun (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Project Management (manage subcontracts, track budgets)	2017
Task 2. Develop detailed sampling plan	Spring 2017
Task 3. Field Sampling	Summer 2017
Task 4. Lab analysis	Fall 2017
Task 5. QA/QC and data management	Winter 2017
Task 6. Draft fact sheet	3/31/2018
Task 7. Final fact sheet	6/30/2018

Background

Imidacloprid, a common neonicotinoid insecticide with many urban uses, has recently been identified as highly toxic to aquatic organisms (Morrissey et al. 2015). Chronic toxicity data indicate that mayflies, chironomids, and mysids can experience long-term effects like immobilization at concentrations <100 ng/L (Morrissey et al. 2015). A recent European Union evaluation of imidacloprid toxicity data (EC 2015) has established a predicted no effect concentration (PNEC) of 4.8 ng/L based on impacts to mayfly nymphs (Roessink et al. 2013). A PNEC specific to the marine or estuarine environment has not been established;

the freshwater PNEC is recommended as the most relevant and protective existing toxicity threshold.

In response to these concerns, the RMP funded a 2016 Special Study, now nearing completion, to assess imidacloprid levels in influent and effluent from Bay Area wastewater treatment plants (Sadaria et al., in prep). Imidacloprid was detected in all samples, with influent levels in the range 58-310 ng/L and effluent levels in the range 84-310 ng/L. Levels in discharged effluent were as much as 60 times greater than the PNEC of 4.8 ng/L. Imidacloprid has also been detected in urban creeks in the Bay Area at levels that exceed this toxicity threshold (Weston et al. 2015).

As both stormwater and wastewater in the Bay Area have been found to contain levels of imidacloprid exceeding a protective aquatic toxicity threshold, monitoring of ambient Bay waters is now recommended. Should dilution and other relevant environmental processes prove insufficient to reduce the levels of imidacloprid below the PNEC of 4.8 ng/L, it may be considered appropriate to classify this widely used pesticide as a Moderate Concern (Tier III) emerging contaminant in San Francisco Bay via the RMP CEC Risk and Management Action Framework (Sutton et al. 2013; Sutton and Sedlak 2015). Common imidacloprid degradates, as well as other neonicotinoid pesticides approved for use in California, will also be monitored as part of this study.

Study Objectives and Applicable RMP Management Questions

This study will provide data essential to determining the placement of imidacloprid and other neonicotinoids in the RMP's tiered risk framework, which guides monitoring and management actions on emerging contaminants in San Francisco Bay (Sutton et al. 2013; Sutton and Sedlak 2015). Existing data on imidacloprid in stormwater and wastewater suggest this pesticide in particular is a priority target for monitoring in Bay water. Management questions to be addressed by this study are the same as those of the overall RMP program, as shown in Table 1.

Table 1. Study objectives and questions relevant to RMP management questions.

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	Compare measured concentrations to toxicity thresholds.	Do findings suggest individual neonicotinoids should be classified as moderate concern, low concern, or possible concern emerging contaminant within the RMP's tiered risk framework? Do data indicate a need for management actions?
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?	Compare levels in different embayments.	Do specific embayments or regions appear to have greater levels of contamination?
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?	*(Previous RMP Special Study directly addresses this management question for imidacloprid.)*	
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.1. What are the effects of management actions on concentrations and mass?		
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?	Review results alongside available projections of use and potential control actions under consideration by state and federal pesticide agencies.	Which anticipated changes or actions are likely to have the greatest impact on neonicotinoid pollution? Are additional/different actions needed?

This monitoring effort would most directly address question 1, determining whether contaminant levels exceed a toxicity threshold. Inferences regarding regional or future pollution patterns could involve interpretation of the data within the context of regional use data and potential changes in use or regulation of this pesticide, all of which may play a role in addressing questions 2 and 5.

In addition, the study will address the established emerging contaminants priority question: What emerging contaminants have the potential to adversely impact beneficial uses of the Bay? The RMP Tiered Risk and Management Action Framework does not include a specific classification for imidacloprid; findings should allow this pesticide to be listed as either a moderate concern (Tier III), low concern (Tier II), or possible concern (Tier I) for San Francisco Bay.

Approach

Ambient Bay Water Sampling

Bay water sample collection will take place in the summer of 2017 as part of the RMP's regular Status and Trends water monitoring cruise. Grab samples of ambient Bay water (1 L, amber glass, 7 day hold time) will be collected at all 22 Bay sites. Two field replicates and a field blank will also be collected.

Analytical Methods

Samples will be analyzed by AXYS Analytical or a comparable laboratory. Per sample analytical costs are estimated to be ~$550 for AXYS.

AXYS Analytical is currently developing a new method to measure imidacloprid, common degradates including imidacloprid urea, and other neonicotinoid pesticides (e.g., acetamiprid, clothianidin, dinotefuran, nitenpyram, thiacloprid, thiamethoxam, imidaclothiz) in (total) water using a high performance liquid chromatograph coupled to a triple quadrupole mass spectrometer (HPLC-MS/MS). The expected instrument detection limit for imidacloprid is expected to be ≤ 2 ng/L, less than half the 4.8 ng/L PNEC (Roessink et al. 2013).

Budget

The following budget represents estimated costs for this proposed special study (Table 3). Efforts and costs can be scaled back by reducing the number of sites sampled.

Table 3. Proposed Budget.

Expense	Estimated Hours	Estimated Cost
Labor		
Project Staff	138	20,500
Senior Management Review	6	960
Project Management		0*
Contract Management		0*
Data Technical Services		2,500
GIS Services		300
Creative Services		750
IT Services		0
Communications		0
Operations		0
Subcontracts		
Name of contractor		
AXYS or comparable lab		13,750
Direct Costs		
Equipment		0
Travel		0
Printing		150
Shipping		1,200
Other		0
Grand Total		40,110

*services included in the base RMP funding

Budget Justification

Field Costs
Field costs are minimized through sample collection during the RMP's 2017 Status and Trends water sampling cruise.

Laboratory Costs
Analytical costs per sample are estimated to be ~$550. For 25 samples, including two field replicates and a field blank, the total analytical costs will be $13,750.

Data Management Costs
Standard data management procedures and costs will be used for this project. Final quality assured data will be uploaded to CEDEN and will be publicly accessible through CD3 (cd3.sfei.org).

Reporting

Results will be provided to the RMP committees in the form of a draft report by 1/31/18, which will be reviewed by ECWG and the TRC. Comments will be incorporated into the final report published by 4/30/18.

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Special Study Proposal: Perfluorinated and Polyfluorinated (PFAS) Compounds in San Francisco Bay: Synthesis and Strategy

Summary: Perfluoroalkyl and polyfluoroalkyl substances (PFASs) are a class of fluorine-rich chemicals with extremely high persistence. Well-studied members of this family have been shown to be highly toxic, while others have received little to no testing. Concentrations of one PFAS, perfluorooctane sulfonate (PFOS), in Bay Area seals and bird eggs in 2004/2006 were some of the highest detected globally. As a result, PFOS has been identified as moderate concern (Tier III CEC) for San Francisco Bay. Recent monitoring suggests decreases in PFOS concentrations in seals and cormorants, likely as a result of changing use patterns that include a nationwide phaseout in 2002.

However, concentrations of other members of the PFAS family, the commonly monitored carboxylates, have remained relatively constant albeit it at substantially lower levels overall. Meanwhile, a number of "precursors," PFAS that degrade to the more persistent PFOS or PFOA, have been detected in sediments. Recent studies of Bay Area stormwater and wastewater suggest that a significant fraction of these precursors are of unknown chemical composition. All PFAS besides PFOS are considered possible concerns (Tier I CEC) for the Bay, as toxicity data are often incomplete or unavailable.

A comprehensive review of PFAS monitoring and toxicity data is needed to determine whether PFOS is the only member of the family to merit regular surveillance. (The RMP currently monitors for 13 perfluorinated chemicals including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonamide (PFOSA).) The purpose of this study is to synthesize the PFAS monitoring to date, to evaluate the classification of these compounds according to the RMP CEC tiers, and to develop a strategy for monitoring PFASs.

Estimated Cost: $56,300

Oversight Group: ECWG

Proposed by: Meg Sedlak, Adam Wong, and Rebecca Sutton (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	***Due Date***
Task 1. Compile data sets, standardize, conduct statistical evaluations	February 2017
Task 2. Evaluation of data in context of recent literature	Spring 2017
Task 3. Assessment of individual PFASs into Tiers (where sufficient information exists)	Spring 2017
Task 4. Draft report	6/31/2017
Task 5. Final report	9/15/2017

Background

Since their first discovery in the mid-1950s, perfluoroalkyl and polyfluoroalkyl substances (PFASs) have been widely used in almost every sector of the economy in such varied applications as providing grease-protection in food-packaging materials, water and stain-repellency for textiles and carpets (e.g., Scotchgard, Gore Tex), coatings for nonstick applications (polytetrafluoroethylene [PFTE] coatings for cookware [Teflon], aerospace, printed circuit boards, cables etc.), and surfactants in semiconductor, metal-coating industries, and firefighting (e.g., AFFF) (Kissa 2001; Wang et al. 2013).

PFASs are carbon chains that have at least one fully fluorinated carbon atom (Buck et al. 2011). In addition to fluorine, the chains may have functional groups such as alcohols, sulfates, carboxylates, ethers, etc. In the case of perfluoroalkyl substances, all of the hydrogens on the carbon are replaced by fluorine, C_nF_{2n+1}–, to which a functional group (e.g., sulfate or carboxylate) is added. Perfluorooctanic acid (PFOA) is an example of a perfluoroalkyl substance. Polyfluoroalkyl substances are not fully fluorinated; an example of polyfluoroalkyl substances are the fluorotelomer alcohols (e.g., 8:2 FTOH $C_8F_{17}CH_2CH_2OH$, which can degrade to PFOA).

As a result of high volume of production and chemical stability, PFASs have been detected throughout the world, even in relatively remote and pristine areas such as the Arctic. In the mid-2000s, PFOS was detected in the human blood supply and the major US manufacturer of perfluoroalkyl sulfonates phased out the production of longer chained PFASs (greater than 8 carbons) (Wang et al 2013). More recently, the USEPA has identified PFOA in 94 drinking water supplies across the country (EWG 2015) and in some instances the concentrations are significantly above the provisional health advisory of 400 ng/L established in 2009 (see letter to Mayor of Hoosick NY- http://www.epa.gov/sites/production/files/2015-12/documents/hoosickfallsmayorpfoa.pdf).

PFOS and PFOA are associated with a number of adverse health effects. Based on the findings of an independent panel reviewing the scientific literature as part of a class action settlement, exposure to PFOA in humans has been associated with six possible outcomes including: testicular cancer, kidney cancer, ulcerative colitis, thyroid disruption, and pregnancy induced hypertension (see http://www.hpcbd.com/Personal-Injury/DuPont-C8/Science-Panel-Probable-Link-Findings.shtml). In laboratory animals, exposure to PFAS has resulted in a myriad of adverse outcomes including low birth weights, compromised immune systems, and tumor formation (Lau et al. 2007). Very few studies have been conducted on the effects of PFAS of estuarine and marine animals. In a study of California sea otters, a significant correlation between the incidence of disease and PFOS/PFOA concentrations in liver was observed (Kannan et al. 2006).

As a result of the adverse impacts, there has been a shift in Europe and North America to shorter-chained carboxylates and sulfates such as perfluorohexanoic acid (PFHxA), perfluorobutanoic acid (PFBA), perfluorobutanesulfonic acid (PFBS) as potential substitutes (Wang et al. 2013); however, the toxicity of these shorter-chained compounds and the precursors to these compounds are not well understood. In addition, there is some evidence to suggest that some precursors (such as the fluorotelomer alcohols) may be more toxic than the perfluorinated carboxylic acids that they degrade to (Phillips et al. 2007).

PFOS and to a lesser extent PFOA have been detected in birds and seals in the Bay Area at some of the highest concentrations observed globally (Sedlak and Greig 2012; Sedlak et al. in prep). The concentrations of PFOS have declined in recent years but nonetheless remain at levels of concern particularly for birds (Custer et al. 2013). Based on the most recent seal and bird data, the concentrations of carboxylates do not show a similar decrease in concentration that was observed for PFOS. There is some concern that some precursors may be degrading to the carboxylates.

Using the RMP's CEC risk and management action framework, the RMP has classified PFOS as a moderate concern (Tier III) chemical, based on the early Bay data for seals and bird eggs (Sutton et al. 2013; Sutton and Sedlak 2015). Remaining compounds have been categorized as a class as possible concerns (Tier I), due largely to limited toxicity data. It is an appropriate time to re-assess the categorization of PFOS and to see whether there is sufficient information to consider re-classifying any of the other PFASs detected in the Bay.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is threefold. First, the project will synthesize existing San Francisco Bay PFAS data collected by the RMP and other scientists into one document.

Secondly, this project will classify the PFASs detected in the Bay using the RMP's tiered risk framework that guides monitoring and management actions on emerging contaminants in San Francisco Bay (Sutton et al. 2013; Sutton and Sedlak 2015). Currently, PFOS is placed in Tier III (Moderate concern); all other PFASs have been placed in Tier I (Possible concern). This study would review the literature to confirm that the PFOS classification is still appropriate in light of new information and, in the cases where there is sufficient information, to classify other PFASs detected.

Third, this project will propose a monitoring strategy for the RMP for PFAS. At present, only cormorant eggs (triennial) and sportfish (every five years) are routinely monitored under Status and Trends for a subset of PFASs that includes PFOS and PFOA (13 analytes total).

PFAS includes quite a broad class of compounds comprising thousands of chemicals. It is neither logistically nor financially feasible to measure each and every one of these chemicals. Strategic decisions will need to be made about which compounds to monitor, and in which matrices.

In the absence of information regarding which chemicals are currently being used, it may be possible to use more generalized techniques to quantify PFASs. Houtz and Sedlak (2012) developed a method for measuring total PFAS precursors levels without requiring molecular identification of each one. Using this method, Houtz and Sedlak estimated that on average 70 % of Bay Area storm water is composed of unidentified precursors. Techniques such as this will be evaluated as potential additions to the RMP monitoring strategy.

Table 1. Study objectives and questions relevant to RMP management questions.

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	Synthesize disparate data sets and evaluate concentrations to recent literature.	This information will be used to classify chemicals in the RMP Tiers.
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?	Evaluate spatial distributions.	South Bay seal and cormorant eggs have higher concentrations of PFOS/PFOA.
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?	Synthesis will include data on stormwater and effluent pathways.	Estimation of loads to the Bay from wastewater treatment facilities and storm water runoff.
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.1. What are the effects of management actions on concentrations and mass?	Evaluate temporal trends in biota.	Conduct statistical analyses of data to determine potential trends.
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?	Review predicted manufacturing trends as well as available data on degradation of precursors to end-products PFOS/PFOA.	Projections may inform classification in Tiers.

This effort would most directly address questions 1 and 4.

Approach

Synthesis

The synthesis will include the following studies focused on the San Francisco Bay:

- Harbor seals. Blood from harbor seals collected in 2004 through 2014 and analyzed for PFASs (Sedlak and Grieg 2012; Sedlak et al. in prep).
- Cormorant eggs. Since 2006, triennial sampling of cormorant eggs have been analyzed for a subset of PFASs as part of the Status and Trends program. Similar to seals, distinct spatial and temporal patterns are evident (Sedlak and Grieg 2012; Sedlak et al. in prep). Data from 2006, 2009, 2012, and 2016 (assuming it is available in time) will be included.

- Fish. San Francisco Bay Sportfish were collected in 2009 and 2014 as part of the RMP Status and Trends monitoring effort and analyzed for PFAS (Davis et al. 2011). In addition, prey fish were collected in 2009, 2010, 2011, and 2012 and analyzed for PFAS (Sedlak and Grieg 2012; Sedlak et al. in prep).
- Mussels. Bay Mussels were collected in 2009/2010 as part of a special study conducted by NOAA mussel watch and analyzed for PFAS (Dodder et al 2014).
- Water. Ambient Bay water was analyzed in 2009 (Klosterhaus et al. 2013) and an urban creek in the South Bay in 2007 (Plumlee et al. 2008).
- Sediment. Bay sediment samples were collected and analyzed in 2004 for PFAS (Higgins et al. 2005) and in 2012 (Benskin et al. 2013).
- Stormwater. Stormwater samples were collected from 10 Bay Area watersheds and analyzed for PFAS in 2010 and 2011(Houtz and Sedlak 2012).
- Effluent. Effluent has been analyzed for PFAS (Houtz et al. 2016) as well as several of the precursors (Benskin et al. 2013).
- Groundwater. Shallow groundwater was collected from the South Bay in 2007 and analyzed for PFAS (Plumlee et al. 2008).

An outline of the synthesis is presented in the Appendix.

Strategy

As part of the synthesis, a monitoring design for PFAS will be proposed that indicates: the matrix, spatial distribution, frequency, and analytes. We will vet the proposed strategy and classification of compounds with known PFAS experts including Derek Muir and Jennifer Field as well as the ECWG and TRC. We anticipate that the PFAS strategy will be updated in future years as part of the CEC strategy review.

Budget

The following budget represents estimated costs for this proposed special study (Table 3).

Table 3. Proposed Budget.

Personnel	**Budget**
Project Staff	$44,450
Senior Management Review	$1,930
Contract Management	NA
Data Technical Services	$7,460
GIS Services	$960
Honorarium (J Field)	$1,500
Total	$56,300

Reporting

Results will be provided to the RMP committees in the form of a draft report by 6/31/17. Comments will be incorporated into the final report published by 9/30/17.

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Appendix: Outline of the PFAS Synthesis and Strategy Report

1. RMP Monitoring of PFASs in San Francisco Bay
    a. PFASs: Structure and Uses
    b. Growing Concerns: Ubiquitous Contaminant, Hot Spots, Toxicity Studies
    c. PFAS Sources and Pathways
    d. Fate in the Environment: transformation processes and terminal degradation products
    e. Management Actions – brief summary
        1. Voluntary phase out C8; PFOA Stewardship Program
        2. Alternatives – Regrettable substitutions?
2. Summary of PFAS Occurrence and Trends
    a. PFASs in San Francisco Bay: The Abiotic Environment
        i. Water
        ii. Sediment
    b. PFASs in San Francisco Bay: Biota
    c. PFAS in Mussel
    d. PFASs in San Francisco Bay Fish
        i. Prey fish
        ii. Sportfish
    e. PFASs in San Francisco Bay Aquatic Bird Eggs
        i. PFASs in Double-crested Cormorant Egg
            1. Spatial and temporal variation
    f. PFASs in San Francisco Bay Harbor Seals
        1. Spatial and temporal variation
3. PFAS Contamination and Bay Impairment
    a. Risks to Humans: PFAS Levels in Fish Are Safe for Human Consumption
    b. Risks to Wildlife:
        i. PFASs Pose ? Risks to Benthic Organisms
        ii. PFASs Pose ? Risks to Fish
        iii. PFASs Risk to Birds
        iv. PFASs Pose Risks to Harbor Seals
    c. Potential for Impairment: Summary
4. PFAS Pathways and Loads to San Francisco Bay
    a. Pathways of PFASs to the Bay: Stormwater and Large Tributary Inputs
    b. Pathways of PFAS to Bay: Effluent
    c. Pathways to the Bay: Groundwater
    d. Pathways to the Bay: Contaminated sites –Former landfills, Use of AFFF at Spills/ Airports/ Refineries
    e. Loadings of PFASs to the Bay
5. Past and Future Trends in Contamination
    a. Declining Levels of PFOS in San Francisco Bay Biota
    b. Trends in other PFASs
        i. PFOA and other Carboxylates
    c. Trends in PFASs Observed in Wastewater and Sediment
    d. Anticipated Future Trends
        i. ?Fluorotelomer?

ii. Shorter chain
iii. Polyfluorinated
iv. Other markets – BRIC -PFOS?

6. CEC Strategy: PFAS Tiers, Monitoring and Management Strategy
    a. Classification for PFOS
    b. Recommendation for classification PFOA
    c. Recommendation for other PFASs
    d. Monitoring Strategy (Table)
        i. Abiotic
        ii. Biotic
            1. Target organisms

    e. Management Actions
        i. Federal
            1. Voluntary phase out C8 PFOS
            2. PFOA stewardship
            3. SNURs
        ii. State
            1. RWQCB Action Plan
            2. Potential Prop 65

Special Study Proposal: Phosphate Flame Retardants in Ambient Bay Water

Summary: California's past implementation of unique flammability standards has resulted in decades of flame retardant additives in consumer goods. RMP-funded monitoring of ambient Bay water in 2013 revealed the presence of numerous phosphate flame retardants. Some South Bay samples exhibited levels of one particular flame retardant, triphenyl phosphate (TPhP), which approached an established marine aquatic toxicity threshold. New furniture testing data also reveal key flame retardants in current use that have yet to be monitored. The proposed study would screen ambient water samples from San Francisco Bay to determine whether levels of TPhP or other widely used phosphate flame retardants commonly exceed aquatic toxicity thresholds. Findings are necessary to determine whether these chemicals have been appropriately classified as "possible concerns" (Tier I) within the RMP's Tiered Risk Framework for contaminants of emerging concern (CECs), and may influence ongoing efforts within state agencies aimed at reducing environmental contamination and ecological impacts of flame retardants.

Estimated Cost: $47,125

Oversight Group: ECWG

Proposed by: Rebecca Sutton (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Project Management (write and manage sub-contracts, track budgets)	2017
Task 2. Develop detailed sampling plan	Spring 2017
Task 3. Field Sampling	Summer 2017
Task 4. Lab analysis	Fall 2017
Task 5. QA/QC and data management	Winter 2017
Task 6. Draft report	5/31/2018
Task 7. Final report	8/31/2018

Background

The state of California has implemented unique flammability standards for consumer products. In response to nationwide phase-outs of polybrominated diphenyl ether (PBDE) flame retardants, manufacturers began to substitute other flame retardant chemicals in their products in order to meet these standards. One particular class of chemicals used as PBDE replacements are phosphate-containing compounds. Some phosphate flame retardants have

been in use for decades, while others are new. Some have broader industrial uses, such as additives in plastic. Of greater significance, some exhibit notable aquatic toxicity or endocrine-disrupting properties in laboratory tests. Others have received little study.

The RMP funded a Special Study in 2014 that detected some of these phosphate flame retardants in Bay water, sediment, and biota (Sutton et al. 2014, 2015). Ambient Bay water measurements indicated phosphate flame retardants were widely detected in San Francisco Bay. Tris (2-chloroehtyl) phosphate (TCPP) was typically the most abundant phosphate flame retardant in Bay water samples, followed by tris (2-butoxyethyl) phosphate (TBEP) and TPhP (Table 1).

Phosphate flame retardants were more concentrated in southern parts of the Bay, where surface waters experience the least amount of mixing with non-effluent flow and have the highest hydraulic residence time compared to other segments. The average total concentration of phosphate flame retardants in South and Lower South Bays was four times higher than in the rest of the Bay (Sutton et al. 2014). Averages of all individual phosphates were also higher in southern parts of the Bay (Sutton et al. 2014). San Francisco Bay has higher levels of contamination for most phosphate flame retardants relative to other estuarine or marine regions (Table 1). However, these findings are based on only 10 ambient Bay surface water samples.

Of greater concern than simple detection, some South Bay samples exhibited levels of TPhP approaching the marine aquatic toxicity threshold of 370 ng/L (predicted no effect concentration [PNEC]; ECHA 2014). The RMP's tiered risk and management action framework currently lists alternative (non-PBDE) flame retardants, which includes phosphate flame retardants, as a possible concern (Tier I) for the Bay due to insufficient monitoring and toxicity data. While TPhP was found to exceed a marine toxicity threshold, the limited number of exceedances did not support classification as a moderate concern (Tier III) for the Bay.

Should additional monitoring indicate such levels are common, this flame retardant could be considered to pose potential risks to Bay wildlife, potentially supporting the listing of TPhP as a moderate concern (Tier III) emerging contaminant for San Francisco Bay. The proposed study is designed to fill this critical data gap concerning the frequency of detections at or near a key toxicity threshold. Findings from the proposed study should provide sufficient data for TPhP and other phosphate flame retardants to be listed as either a moderate concern (Tier III), low concern (Tier II), or possible concern (Tier I) for the Bay.

Starting in 2014, changes to California's flammability standards may lessen use of chemical flame retardants in some consumer goods, and therefore possibly reduce contamination in the Bay. Monitoring may provide initial information as to the potential impacts of these actions. Unfortunately, recent foam furniture testing suggests widespread use of newly identified phosphates such as tertbutylphenyl diphenyl phosphate and isopropylphenyl diphenyl phosphate, which have not been examined in the Bay (Heather Stapleton, personal communication). USEPA Chemical Data Reporting from manufacturers in 2012 also suggests use of compounds not yet monitored, such as trixylyl phosphate, resorcinol bisdiphenyl phosphate, isodecyl diphenyl phosphate, di-tert-butylphenyl phenyl phosphate, and isopropylated triphenyl phosphate.

Table 1: Phosphate flame retardants in estuarine or marine environments (ng/L).

Location	Year	TCEP	TCPP	TDCPP	TPhP	TBP	TCrP	TBEP	TEHP	EHDPP	T35DMPP	T2IPPP	Reference
Estuarine / Marine													
San Francisco Bay	2013	6.9 - 300	44 - 2,900	5.3 - 450	13 - 300	3.3 - 39	ND - 5.5	24 - 840	ND - 4.2	ND - 2.3	ND	ND	*this study*
Southern California Bight	2006 - 2007	ND	ND - 56										Vidal-Dorsch et al. 2012
River Elbe Estuary	2010	5 - 20	40 - 250	6 - 30	0.3 - 4	2 - 7.5		ND - 80					Bollmann et al. 2012
North Sea (German Bight)	2010		3 - 28					ND - 6					Bollmann et al. 2012

Abbrev.	**Flame retardant**
Phosphates	
TCEP	Tris (2-chloroethyl) phosphate
TCPP	Tris (1-chloro-2-propyl) phosphate (multiple isomers)
TDCPP	Tris (1,3-dichloro-2-propyl) phosphate
TPhP	Triphenyl phosphate
TBP	Tri-n-butyl phosphate
TCrP	Tricresyl phosphate
TBEP	Tris (2-butoxyethyl) phosphate
TEHP	Tris (2-ethylhexyl) phosphate
EHDPP	2-Ethylhexyl diphenyl phosphate
T35DMPP	Tris (3,5-dimethylphenyl) phosphate
T2IPPP	Tris (2-isopropylphenyl) phosphate

Study Objectives and Applicable RMP Management Questions

This study will provide data essential to determining the placement of a number of phosphate flame retardants in the RMP's tiered risk framework, which guides monitoring and management actions on emerging contaminants in San Francisco Bay (Sutton et al. 2013; Sutton and Sedlak 2015). Previous detections suggest triphenyl phosphate in particular may require additional study (Sutton et al. 2014). Management questions to be addressed by this study are the same as those of the overall RMP program, as shown in Table 2.

Table 2. Study objectives and questions relevant to RMP management questions.

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	Compare measured concentrations to toxicity thresholds.	Do findings suggest specific phosphate flame retardants should be classified as moderate concern, low concern, or possible concern emerging contaminant within the RMP's tiered risk framework? Do data indicate a need for management actions?
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?	Compare levels in different embayments.	Do specific embayments or regions appear to have greater levels of contamination?
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?		
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.1. What are the effects of management actions on concentrations and mass?	Compare measurements to existing data from 2013.	Are there suggestions of trends in contamination levels, taking into account data limitations and differences in methods?
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?	Review results alongside available projections of use and potential control actions under consideration by state and federal agencies.	Which anticipated changes or actions are likely to have the greatest impact on phosphate flame retardant pollution? Are additional/different actions needed?

This monitoring effort would most directly address question 1, determining whether contaminant levels exceed a toxicity threshold. Inferences regarding regional pollution patterns and temporal trends or future predictions could involve interpretation of the data within the context of Bay Area geography, existing data, and potential changes in use or regulation of flame retardants, all of which may play a role in addressing questions 2, 4, and 5.

In addition, the study will address the established emerging contaminants priority question: What emerging contaminants have the potential to adversely impact beneficial uses of the Bay?

Approach

Ambient Bay Water Sampling

Bay water sample collection will take place in the summer of 2017 as part of the RMP's regular Status and Trends water monitoring cruise. Grab samples of ambient Bay water (2 L, amber glass, 14 day hold time) will be collected at all Bay sites. Two field replicates and a field blank will also be collected. Some phosphate flame retardants are also used as plasticizers, so exposure to plastics will be avoided.

Analytical Methods

Samples will be analyzed by Dr. Da Chen of Southern Illinois University. Dr. Chen will measure the total suspended solids (TSS) of each sample, then characterize contaminants within the aqueous and solid phases using highly sensitive liquid chromatography–triple quadrupole mass spectrometry (LC–QQQ-MS/MS) based analysis methods (Chen et al. 2012; Chu et al. 2011). Limits of detection are typically in the range of 0.1 ppb.

Dr. Chen has agreed to undertake method development to add newly identified phosphate flame retardants, including tertbutylphenyl diphenyl phosphate and isopropylphenyl diphenyl phosphate, to his already extensive list of target analytes. Analysis is expected to cost around $600 per sample.

Budget

The following budget represents estimated costs for this proposed special study (Table 3). Efforts and costs can be scaled back by reducing the number of sites sampled.

Table 3. Proposed Budget.

Expense	Estimated Hours	Estimated Cost
Labor		
Project Staff	168	24,068
Senior Management Review	6	960
Project Management		NA*
Contract Management		NA*
Data Technical Services		4,500
GIS Services	3	280
Creative Services	4	317
IT Services		0
Communications		0
Operations		0
Subcontracts		
Name of contractor		
Dr. Chen, SIU, or comparable lab		15,000
Direct Costs		
Equipment		0
Travel		0
Printing		0
Shipping		2,000
Other		0
Grand Total		47,125

*services included in the base RMP funding

Budget Justification

Field Costs
Field costs are minimized through sample collection during the RMP's 2017 Status and Trends water sampling cruise.

Laboratory Costs
Analytical costs per sample are estimated to be $600. For 25 samples, including two field replicates and a field blank, the total analytical costs will be $15,000.

Data Management Costs
Standard data management procedures and costs will be used for this project. Final quality-assured data will be uploaded to CEDEN and made publicly available through CD3.

Reporting

Results will be provided to the RMP committees in the form of a draft report by 5/31/18, which will be reviewed by ECWG and the TRC. Comments will be incorporated into the final report published by 8/31/18.

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Special Study Proposal:
Emerging Contaminants Strategy

Summary:

Increasing interest in emerging contaminants issues by the San Francisco Bay Regional Water Board, RMP stakeholders, and the general public is reflected in headline news as well as policy actions at local, state, and federal levels. The amount of effort needed to manage the RMP Emerging Contaminants Strategy has increased significantly in recent years. Core deliverables have been tracking new information regarding contaminant occurrence and toxicity and updating the RMP's Tiered Risk and Management Action Framework. New requests for information include assisting the Water Board with emerging contaminants action plans. Coordination of *pro bono* analyses by partners, such as BACWA and universities, is another rapidly expanding component of strategy implementation. A Bay-specific contaminant transport model will also be revised to incorporate better information on pathways, in response to a need for improved modeling capabilities identified by stakeholders and experts. Finally, an exploration of quantitative passive sampling capabilities has been identified as another near-term strategic goal. For these reasons, this proposal requests an increase in funding for managing the RMP Emerging Contaminants Strategy.

Estimated Cost: $50,000
Oversight Group: ECWG
Proposed by: Rebecca Sutton (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Information gathering from a variety of sources throughout the year, including presentations at scientific conferences	12/31/2017
Task 2. Assist Water Board and other stakeholders with science summaries relating to policy including emerging contaminants action plans and comment letters regarding proposed actions of other agencies	12/31/2017
Task 3. Present an update of emerging contaminants strategy, ongoing or completed special and pro bono studies, and new studies to the Steering Committee	12/31/2017
Task 4. Review tiered monitoring and management risk framework, present findings to the Water Board	12/31/2017
Task 5. Provide brief update to the RMP CEC Strategy document, including revised tiered framework tables and multi-year plan	12/31/2017
Task 6. Update existing Bay contaminant transport model with improved stormwater and runoff information	12/31/2017
Task 7. Inform experts and stakeholders regarding the practical application of quantitative passive sampling methods in estuarine settings	12/31/2016

Background

The science and management of contaminants of emerging concern (CECs) is an area of dynamic recent development. In 2015, the House and Senate both passed bills that would alter the primary legislation governing production and use of chemicals in the U.S., the federal Toxic Substances Control Act. While a single bill has not yet emerged from the reconciliation process, passage of legislation designed to modify a law that has been unchanged for 40 years is a clear sign of the growing concern surrounding the widespread introduction of thousands of chemicals into commerce without significant testing to establish safety for humans or wildlife. The general public has also become increasingly engaged on issues of chemical safety and potential ecological harm, informed by headlines in major newspapers across the country.

The RMP, a global leader on contaminants of emerging concern (CECs), stays ahead of the curve by identifying problem pollutants *before* they can harm wildlife. The RMP has completed a strategy document outlining a comprehensive, forward-looking approach to addressing CECs in San Francisco Bay (Sutton et al. 2013). The RMP's CECs strategy consists of three major elements. First, for contaminants known to occur in the Bay, the RMP evaluates relative risk using a Tiered Risk and Management Action Framework. This risk-based framework guides future monitoring proposals for each of these contaminants. The second element of the strategy involves review of scientific literature and other aquatic monitoring programs to identify new contaminants for which no Bay data yet exist. Finally, the third element of the strategy consists of non-targeted monitoring, including broadscan analyses and development of bioanalytical tools. In 2016, this strategy document will undergo a major revision to stay current with a wealth of recent scientific findings and management actions.

For the RMP CECs Strategy to remain relevant and timely, it needs annual updates with new information on analytical methods and study findings from the RMP and others. Funds are needed to review new results, track research conducted elsewhere, and keep stakeholders apprised of findings. Coordination of pro bono analyses is another rapidly expanding component of the strategy fund. At the same time, it is important for the RMP to provide relevant, objective science to inform the growing number of policy actions concerning emerging contaminants, an increasing demand on staff time.

In 2016, the RMP Steering Committee approved $33,000 for this strategy support task, recognizing especially the increased need for coordination of pro bono studies. An additional $15,000 was budgeted for revision of the strategy document, for a total of $48,000. With the potential for increased resources directed towards emerging contaminants in 2017, including specific deliverables regarding modeling and the exploration of new technologies (passive sampling), the recommended budget needed for managing the RMP CEC Strategy is $50,000. Additional budget details are provided in the following sections.

Study Objectives and Applicable RMP Management Questions

Table 1: Study objectives and questions relevant to RMP management questions

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	Compare existing occurrence data with new toxicity information reported in the scientific literature. Evaluate future monitoring needs and toxicity data gaps.	Does the latest science suggest a reprioritization of chemicals as we learn more about them? Which newly identified contaminants merit further monitoring?
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?	Does new knowledge including recently published toxicity data and/or source/pathway information suggest different relative risks for any of the five subembayments?	What are the key regional influences on different subembayments that impact concentrations, masses, and potential risk of emerging contaminants?
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?	Refine modeling capabilities through incorporation of improved data on pathways. Does new research in other regions provide insight as to key sources, pathways, loadings, and processes that affect impacts of emerging contaminants?	Are relative levels of contaminants in different matrices or subembayments consistent with our expectations for various contaminant processes?
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.1. What are the effects of management actions on concentrations and mass?	Does trend data from other regions suggest likely trends in the Bay? Which new management actions are likely to impact contaminant levels?	Are additional or different actions needed to reduce levels below aquatic toxicity thresholds?
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?	Do data on production, use, and source trends in the scientific and trade literature provide a means of prioritizing relative risk of Bay contaminants?	Do production, use, and source trends suggest likely changes in the relative risk of specific emerging contaminants?

Emerging contaminants strategy work most directly addresses questions 1, 3, and 5, by assuring that all manner of relevant new information is brought to bear in evaluating the relative risk of emerging contaminants to Bay wildlife. For example, a new study identifying a lower toxicity threshold for a particular contaminant might suggest that the risk tier in which that contaminant had been placed should be revised.

In addition, the study will address the emerging contaminants priority question: What emerging contaminants have the potential to adversely impact beneficial uses of the Bay?

Approach

The emerging contaminants strategy funding supports the review of key information sources throughout the year. These sources include:

- Abstracts and newly published articles in key peer-reviewed journals (e.g., Environmental Science and Technology, Environmental Toxicology and Chemistry, Environment International)
- Documents produced by other programs (e.g., USEPA, Environment Canada, European Chemicals Agency, Great Lakes CEC Program)
- Abstracts and proceedings from relevant conferences (e.g., Society of Environmental Toxicology and Chemistry, International Symposium on Brominated Flame Retardants)

In addition, strategy funding allows staff to provide additional services, such as:

- Numerous presentations, briefings, and stakeholder interactions
- Scientific assistance to the Water Board as the agency prepares emerging contaminant action plans
- Scientific assistance to stakeholders engaged in emerging contaminants policy
- Coordination of pro bono analyses
- Improved modeling capabilities: The San Francisco Bay transport model will be updated with a four-fold increase in stormwater and runoff sources. Estimated flows from these 300+ watersheds will be based on a combination of an updated Regional Watershed Spreadsheet Model and USGS streamflow data. The model will then be used to predict the distribution in space and time of each watershed's contribution to the Bay waters, calculated across a full water year.
- Webinar or similar platform to inform stakeholders and experts as to the potential advantages and disadvantages associated with incorporating quantitative passive sampling methods into estuarine monitoring for emerging contaminants

The following table lists the specific tasks to be completed and their due dates.

Deliverable	**Due Date**
Task 1. Information gathering from a variety of sources throughout the year, including presentations at scientific conferences	12/31/2017
Task 2. Assist Water Board and other stakeholders with science summaries relating to policy including emerging contaminants action plans and comment letters regarding proposed actions of other agencies	12/31/2017
Task 3. Present an update of emerging contaminants strategy, ongoing or completed special and pro bono studies, and new studies to the Steering Committee	12/31/2017
Task 4. Review tiered monitoring and management risk framework, present	12/31/2017

findings to the Water Board	
Task 5. Provide brief update to the RMP CEC Strategy document, including revised tiered framework tables and multi-year plan	12/31/2017
Task 6. Update existing Bay contaminant transport model with improved stormwater and runoff information	12/31/2017
Task 7. Inform experts and stakeholders regarding the practical application of quantitative passive sampling methods in estuarine settings	12/31/2016

Budget

The following budget represents estimated costs for 2017 Emerging Contaminants Strategy.

Table 2. 2017 Emerging Contaminants Strategy budget

Deliverables	**Budget**
Tasks 1-7: Information gathering from a variety of sources throughout the year, including presentations at scientific conferences; Assist Water Board and other stakeholders with science summaries relating to policy including emerging contaminants action plans and comment letters regarding proposed actions of other agencies; Present an update of emerging contaminants strategy, ongoing or completed special and pro bono studies, and new studies to the Steering Committee; Review tiered monitoring and management risk framework, brief the Water Board; Provide brief update to the RMP CEC strategy document, including revised tiered framework tables and multi-year plan; Improve Bay contaminant transport models; Explore potential for quantitative passive sampling methods in estuarine settings	$50,000

Budget Justification

Funding for managing the CEC Strategy has traditionally covered updates to the Tiered Risk and Management Framework (element one of the RMP CEC strategy), review of the state of the science concerning CECs and interaction with other monitoring groups (element two), and interpretation of the findings of non-targeted analysis (element three) to determine new monitoring priorities.

Additional demands placed on the RMP's emerging contaminants team in recent years include: a) scientific assistance to the Water Board as agency staff prepare action plans for specific CECs; b) increased engagement with stakeholders (e.g., briefings for the Water Board and the RMP Steering Committee); c) scientific advisory support for the Water Board and other stakeholders concerning relevant policy proposals and actions at the local, state, and federal levels (e.g., USEPA proposed significant new use rules); d) increasing coordination of pro bono analyses that leverage RMP funds; and e) improved contaminant transport modeling capabilities. To assure that the RMP is able to provide cost-effective expertise to address these demands, this proposal requests a higher level of funding for 2017 to assure that the policies that are developed are based on sound science.

In 2016, the RMP Steering Committee approved $33,000 for this strategy support task, recognizing especially the increased need for coordination of pro bono studies. In 2017, we are requesting $50,000 in order to cover the new demands listed in the preceding paragraph. This increase in cost is justified by the cost to perform the work. For example, developing a single memo for the Water Board describing the state of science and policy for a particular contaminant for which an action plan is being developed may require 20 hours of senior staff time @ $150/hr, resulting in an expenditure of $3,000.

By providing funding for the emerging contaminants strategy, the RMP can be assured it is getting "the most bang for its buck," targeting the highest priority contaminants among the many thousands in commerce and potentially discharged to the Bay. The RMP is a global leader in CEC monitoring, yet it must be efficient and pragmatic in the face of finite resources. An increase in funding for this task will allow for strategic thinking using the latest science, so that the RMP can continue to generate the information water managers need to effectively address emerging contaminants in the Bay.

Reporting

A number of RMP CEC Strategy presentations (Emerging Contaminants Workgroup, Steering Committee, and Annual Meeting) and briefings (Water Board, others as needed) provide opportunities to report on this work. A brief update to the RMP CEC Strategy, including revised tiered framework tables and multi-year plan, represents another key reporting mechanism for the RMP.

References

Sutton R, Sedlak M, Davis J. 2013. Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations. SFEI Contribution 700. San Francisco Estuary Institute, Richmond, CA.
http://www.sfei.org/documents/contaminants-emerging-concern-san-francisco-bay-strategy-future-investigations

Special Study Proposal: Triclosan in Small Fish

Summary: The RMP classification of the widely used antibacterial ingredient triclosan as an emerging contaminant of low concern (Tier II) for San Francisco Bay is based on a relatively small amount of data. A recent study of a West Coast estuary suggests monitoring in small fish may be a more sensitive indicator of impact; these data are lacking for San Francisco Bay. Characterization of triclosan in whole fish composites of juvenile salmon from the Puget Sound indicates levels of potential concern, despite low concentrations in estuary waters. Food web transfer is suspected of leading to the higher concentrations observed in small fish. The proposed study would screen small Bay fish for triclosan and its metabolite, methyl triclosan, to determine whether levels may pose concerns. These data are essential to appropriately classify triclosan within the RMP's tiered risk framework for contaminants of emerging concern (CECs), and may influence ongoing efforts among stakeholders and local and state agencies aimed at reducing environmental contamination and ecological impacts of this antibacterial agent.

Estimated Cost: $41,300

Oversight Group: ECWG

Proposed by: Rebecca Sutton and Meg Sedlak (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	***Due Date***
Task 1. Project Management (manage subcontracts, track budgets)	2017
Task 2. Develop detailed sampling plan	Spring 2017
Task 3. Field Sampling	Summer 2017
Task 4. Lab analysis	Fall 2017
Task 5. QA/QC and data management	Winter 2017
Task 6. Draft report	4/30/2018
Task 7. Final report	7/31/2018

Background

Triclosan is an antimicrobial chemical used widely in personal care products, such as liquid hand soaps, and many other consumer goods. Triclosan has been detected in Bay sediment and surface water (up to 68 ± 26 ng/L; Kerrigan et al. 2015), with observed concentrations below available aquatic toxicity thresholds (e.g., a predicted no effects concentration [PNEC] of 115 ng/L; EC 2012). Triclosan was not detected in mussels collected from the Bay in 2010 (< 33 ng/g wet weight; see 2013 Pulse of the Bay), though trace levels of the

metabolite methyl triclosan were identified in mussel tissue subjected to non-targeted analysis (Sutton and Kucklick 2015).

Based on the available data for the Bay, the RMP has classified triclosan as a low concern (Tier II) contaminant, according to the tiered risk and management action framework (Sutton et al. 2013). However, recent monitoring in Puget Sound found that though estuary water contained just 5.2 ng/L triclosan (Sinclair Inlet), levels in juvenile salmon averaged 24.4 ng/g (whole fish composites), suggesting considerable food web transfer (Meador et al. 2016).

To assess whether these observed tissue concentrations are a cause for concern, it would be best to compare them to a toxicity threshold that is also based on tissue concentrations, essentially comparing apples to apples. However, this sort of tissue-specific toxicity threshold is not available. Existing toxicological studies on fish provide toxicity endpoints tied to concentrations in water to which the fish are exposed in controlled laboratory environments (e.g., Schultz et al. 2012). Unlike the fish in Puget Sound, the fish in lab studies are exposed to triclosan only through water, and not through the food web. Using a bioaccumulation factor to account for the food-based exposure pathway, we can estimate the hypothetical water concentration that would lead to observed tissue levels in Puget Sound fish. Fish exposed in the lab to this hypothetical, calculated water concentration, and fed food free of triclosan, would be expected to contain the same level of triclosan in their tissues as seen in the Puget Sound fish exposed to triclosan via the food web.

The Puget Sound scientists calculated this hypothetical water exposure concentration to be 271 ng/L. This hypothetical water exposure concentration could then be compared directly to concentrations used in toxicology experiments involving fish raised in a controlled environment that are exposed to triclosan only through the water, not via the food web. The calculated water equivalent level, 271 ng/L of triclosan, is near a level of triclosan (560 ng/L) that has been shown to significantly increase aggressive behavior in fathead minnows when exposed in combination with another widely used antibacterial agent, triclocarban (179 ng/L; Schultz et al. 2012). These two compounds are known to co-occur in the environment, often at comparable levels (Halden and Paull 2005).

The RMP's previous review of triclosan noted data gaps regarding the potential for transfer through the food web to act as a source of additional exposure to wildlife (Klosterhaus et al. 2011). With new findings from the Puget Sound suggesting this may be occurring in a similar West Coast estuary (Meador et al. 2016), there is now stronger motivation to determine whether levels of triclosan in the Bay's small fish may be a potential concern. At present, the estimation method outlined above is the only way to account for the effects of food web transfer using existing toxicity data.

A notable strength of the present proposal is the evaluation of both triclosan and its metabolite, methyl triclosan, in tissue. Methyl triclosan is formed from biological methylation of triclosan. It is more likely to bioaccumulate than triclosan (Bedoux et al. 2012), and may be more toxic (Bedoux et al. 2012), yet it is rarely characterized in monitoring studies.

Of note, while fish can be exposed to higher levels of triclosan from their surroundings, algae and invertebrates are often considered more sensitive (Chalew and Halden 2009). A

number of different aquatic toxicity thresholds for triclosan are available in the literature. Colgate-Palmolive scientists used an unconventional method to develop a PNEC of 1,550 ng/L (Capdevielle et al. 2008). In contrast, a more traditional and conservative method based on acute algal toxicity has led to use of a PNEC of 4.7 ng/L (e.g., von der Ohe et al. 2012). Should the latter threshold be considered more appropriate for San Francisco Bay, the few recent ambient Bay surface water measurements available (up to 68 ± 26 ng/L; Kerrigan et al. 2015) may suggest cause for concern. However, existing data are too few to trigger reclassification of triclosan within the RMP's CEC risk and management action framework (Sutton et al. 2013; Sutton and Sedlak 2015). Until more data are generated, triclosan may remain classified as a low concern (Tier II) for San Francisco Bay.

Study Objectives and Applicable RMP Management Questions

This study will provide data essential to determining the appropriate placement of triclosan in the RMP's tiered risk framework, which guides monitoring and management actions on emerging contaminants in San Francisco Bay (Sutton et al. 2013; Sutton and Sedlak 2015). Existing data on triclosan have led to classification as a low concern (Tier II) contaminant (along with other pharmaceutical and personal care product chemicals monitored; Sutton et al. 2013), but a recent study of Puget Sound suggests small fish may be a more sensitive indicator of exposure and potential concern (Meador et al. 2016). Management questions to be addressed by this study are the same as those of the overall RMP program, as shown in Table 1.

Table 1. Study objectives and questions relevant to RMP management questions.

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	Compare measured concentrations to toxicity thresholds (back-calculated to account for food web magnification).	Do findings suggest triclosan is appropriately classified as a low concern for San Francisco Bay? Do data indicate a need for management actions?
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?		
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?		

4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.1. What are the effects of management actions on concentrations and mass?		
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?	Review results alongside available projections of use and potential control actions under consideration by local, state and federal agencies and organizations.	Which anticipated changes or actions are likely to have the greatest impact on triclosan pollution? Are additional/different actions needed?

This monitoring effort would most directly address question 1, determining whether contaminant levels exceed a toxicity threshold. Inferences regarding future pollution could involve interpretation of the data within the context of use information and potential changes in use or regulation of this antimicrobial pesticide, all of which may play a role in addressing question 5.

In addition, the study will address the established emerging contaminants priority question: What emerging contaminants have the potential to adversely impact beneficial uses of the Bay? The RMP's tiered risk and management action framework currently lists pharmaceuticals and personal care products including triclosan as a low concern (Tier II) for San Francisco Bay; findings would be used to update this classification based on a more sensitive indicator.

Approach

Ambient Bay Small Fish Sampling

Small fish will be collected through a strategic collaboration with an existing sampling effort in the Lower South Bay, the region of the Bay with the greatest likelihood for organism exposure to wastewater-derived chemicals. Dr. James Hobbs (UC Davis), the principal investigator of this on-going effort, has expressed willingness to collaborate.

Mississippi silversides are expected to be an appropriate sentinel species for this study, though others may be considered. Small fish will be shipped whole to AXYS Analytical (or a comparable laboratory) for preparation as whole-fish composites (4-10 individuals per composite, depending on species and size). A total of up to 17 composite samples will be tested, along with one field replicate, one field tissue blank, and a reference sample. Minimum sample size is 2.5 g.

Analytical Methods

Samples will be analyzed by AXYS Analytical or a comparable laboratory. AXYS will soon release a new method to determine both triclosan and methyl triclosan in tissue. The

instrument detection limit for triclosan is expected to be 1 ng/g, while for methyl triclosan it is expected to be in the range of 1-5 ng/g. Per sample analytical costs are estimated to be $440 for AXYS, which includes preparation of composites and lipid analysis as well as chemical analysis.

Budget

The following budget represents estimated costs for this proposed special study (Table 2). Efforts and costs can be scaled back by reducing the number of composites sampled.

Table 2. Proposed Budget.

Expense	Estimated Hours	Estimated Cost
Labor		
Project Staff	168	24,000
Senior Management Review	6	1,300
Project Management		0*
Contract Management		0*
Data Technical Services		4,000
GIS Services		0
Creative Services	6	500
IT Services		0
Communications		0
Operations		0
Subcontracts		
Name of contractor		
AXYS or comparable lab		8,800
Direct Costs		
Equipment		1,000
Travel		500
Printing		0
Shipping		1,200
Other		0
Grand Total		41,300

*services included in the base RMP funding

Budget Justification

Field Costs
Field costs are minimized through sample collection in collaboration with an existing monitoring effort.

Laboratory Costs
Analytical costs per sample are estimated to be $440. For up to 20 samples, including one field replicate, a field blank, and a reference specimen, the total analytical costs will be $8,800.

Data Management Costs
Standard data management procedures and costs will be used for this project. Data will not be uploaded to CEDEN at this time.

Reporting

Results will be provided to the RMP committees in the form of a report. A draft will be provided for review by 4/30/18. Comments will be incorporated into the final report published by 7/31/18.

References

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Strategy for Benthos and Sediment Toxicity Monitoring by the RMP

Estimated Cost: $10,000

Oversight Group: Exposure & Effects Workgroup

Proposed by: Phil Trowbridge

Background

Monitoring for benthic invertebrates and sediment toxicity has been part of the RMP Status & Trends Program for decades. From 2009-2016, a number of special studies have been completed on benthic assessment tools and the causes of moderate sediment toxicity in the Bay. No additional studies are planned. In 2018, the RMP is scheduled to collect the next round of benthic invertebrate and sediment toxicity data. Therefore, the Exposure and Effects Workgroup recommended developing a short strategy document outlining what has been learned over the past 7 years of special studies and how the RMP should proceed in the future with benthic monitoring.

Strategy Document Outline

1. Upcoming management decisions, management utility of the data
    a. Sediment Quality Objectives
    b. Benthic grazer abundance for NMS modeling and studies
    c. Baseline for biological invasions, "step changes" in Bay ecology
    d. Possible endpoint for effects of PAHs in sediment
2. Synthesis of RMP studies on benthos and sediment toxicity methods
    a. Summary of previous work (RMP and others)
    b. Highlight resolved and unresolved issues of management relevance
3. Summarize alternatives to the RMP methods for benthic monitoring
    a. Benthic cameras
    b. In-situ assays
4. Multi-Year Plan for benthos and sediment toxicity monitoring by the RMP
    a. S&T Monitoring Schedule (Note: the EEWG recommends collecting benthos and sediment toxicity data in 2018 as planned. The strategy would guide how that data should be collected and how they should be interpreted.)
    b. Special Studies

Expected document length: 10-20 pages

Deliverables and Schedule

Task 1. Stakeholder engagement on management relevance. 1-2 calls with interested stakeholders. Discussion at the TRC and EEWG meetings (by 6/15/17)

Task 2. White paper with Multi-Year Plan for Benthic Sampling (draft by 3/30/17 for TRC and EEWG meetings; final by 9/30/17 in time for multi-year planning workshop)

Budget

$10,000

PS/SS: Estrogen receptor *in vitro* assay linkage studies

Estimated Cost: $45,000 for 2017.
Oversight Group: Emerging Contaminants Workgroup and Exposure and Effects Workgroup
Proposed by: Nancy Denslow (University of Florida)

Proposed Deliverables and Time Line

Deliverable		Completion Date
Task 1:	**ER dose response linkage in vitro/in vivo**	**12 months**
Task 2:	**Demonstrate usefulness of assay with environmental samples**	**12 months**
Task 3:	**Report**	**12 months**

BACKGROUND

There is no longer any question that pharmaceuticals and personal care products are found in surface waters in our environment at concentrations that have biological activities in aquatic organisms (reviewed in (Cooke et al. 2013). Alterations among higher order endpoints have been observed including alterations of gonadal sex differentiation, causing a disproportionate female sex ratio, changes in secondary sex characteristics, reduction in reproduction and growth, and alterations of courting behavior, among others (Matthiessen and Sumpter 1998; Rodgers-Gray et al. 2001; Sarria et al. 2011; Adedeji et al. 2012; Baumann et al. 2014). The most studied are chemicals that either mimic the function of 17β-estradiol (E2) or interfere with the biosynthesis or metabolism of the endogenous hormone. As might be anticipated, it is now recognized that the activities of multiple estrogen mimics when present together in mixtures in an effluent are additive (Brian et al. 2007), making it problematic to monitor effluents using the "one chemical at a time" approach.

While the gold standard is to measure higher order alterations directly *in vivo*, the experiments are costly in both time and money and require the use of hundreds to thousands of fish and furthermore are impractical to run routinely. Based on the recommendations of the National Academy of Sciences (NRC 2007), toxicologists are turning their attention to high throughput *in vitro* assays that are specific for mechanism of action and which are much more cost effective than *in vivo* assays (Dix et al. 2007; Judson et al. 2009; Martin et al. 2009; Conley et al. 2016). However, before these assays can be used in a regulatory framework, it is important to establish linkages from the *in vitro* assays to *in vivo* end points. While some studies have done this with fresh water fish, studies with estuarine fish are lacking. For the fresh water fish it is now clear that affinity of a chemical for the ligand binding domain of the estrogen receptor is a good predictor of higher order effects (Miyagawa et al. 2014). A strong linkage between the two for estuarine fish would enable managers to monitor routinely for estrogens in San Francisco Bay with a bioanalytical test. The gap in being able to predict *in vivo* endpoints from *in vitro* assays precludes this approach from being widely used. In this project, we will reduce the gap, clearly linking concentrations that are necessary for activity both *in vitro* and *in vivo*. Our preliminary data obtained from the phase 1 application to SFEI, clearly shows this will be

possible to do. In addition, we will pilot a small study to see how the *in vitro* assay would work on both water and contaminated sediments in San Francisco Bay. Recent publications suggest that sediment may be a sink for endocrine active compounds (Sangster et al. 2014; Zhang et al. 2015).

Study Objective and Applicable RMP Management Question

Our first phase study clearly showed that it would be possible to link *in vitro* ER assays to *in vivo* endpoints. Our conclusion was that the concentrations of estrogens needed to be above the EC_{50} point for the *in vitro* assays to see effects *in vivo* with *Menidia*. However, the dose response curve for the *in vivo* endpoints was broad and we missed several critical doses that would narrow the comparison from *in vitro* to *in vivo*. While the data allows us to extrapolate those values, it would be better to pinpoint the comparison a little more closely and also to repeat the whole study to see if the relationships continue to hold. Further, we intend for this assay to become a standard monitoring tool and will develop a pilot study to measure estrogen equivalencies at 6 locations in the bay, testing both the water and sediments, to determine the usefulness of the approach. Results from this study will begin to enable managers to determine whether or not additional cleanup is necessary for treated effluents that are disposed into sensitive estuarine environments. This work will not only be important for California, but also for other states that border marine environments and which may still be using old technologies for water treatment and discharge. The overall objective of this effort is to develop a tool that will assist in the identification of chemicals of emerging concern that are adversely affecting biota. This study would address the following RMP management question (MQ):

MQ1. Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?

This targeted study will have two objectives:
(1) To repeat the *in vivo* portion of the linkage study with tighter concentrations around the likely EC_{50} for *in vivo* responses.
(2) To test water and sediment from 6 locations in San Francisco Bay for estrogenic equivalencies as a pilot test for this approach.

Study Plan

In phase 1, we tested both strong and weak estrogens with the *in vitro* estrogen transactivation assay from InVitrogen. We also performed *in vivo* assays with two life stages, larvae (10-17 days post hatch (dph)) and juveniles (30-58 dph) and examined higher order endpoints including for larvae, survival, growth and gene expression and for juveniles, gonadal tissue differentiation, growth and gene expression. For this phase-2 project, we will concentrate our efforts on 17β-estradiol (E2), as a prototypic estrogen for which we will develop the linkage from *in vitro* to *in vivo*. We will use the juvenile life stage of *Menidia beryllina* (inland silversides), as this stage provided the most sensitivity for higher order effects from estrogens. For this assay we will measure gonadal tissue differentiation, growth and hepatic gene expression for two genes, whose expression in juvenile fish depends on the presence of E2. We will index estrogen equivalency concentrations required for altering higher order endpoints with biochemical responses within the fish and responses obtained with the commercially available estrogen receptor (ER) transactivation assay from InVitrogen. These linkages will enable the use of *in vitro* assays as measurements of both exposure and effect. The concentrations required for both *in vivo* and *in vitro* assays will be quantified to determine reference concentrations above which effects may be expected.

Task 1:	ER dose response linkage in vitro/in vivo

Building on our previous work, we will start with 30 dph Menidia and treat them with 7 concentrations of E2, including 2, 10, 20, 40, 80, 200 and 500 ng E2/L compared to control (no E2). The EC_{50} for the *in vitro* assay is 20 ng E2/L and we expect the curve for *in vivo* higher order effects to be slightly shifted to the right. We know from previous work that 200 ng/L is close to the plateau and by 500 ng/L we have reached the plateau (Fig. 1). The test chemicals will be mixed with a small volume of triethylene glycol (TEG) as a carrier to ensure the chemical gets into the water phase. Dilution water will dechlorinated tap water adjusted to 15 ppt salt (using Instant Ocean) and temperature will be controlled to 23 ± 1 °C, following our modifications of the standardized test guidelines for early life testing (US-EPA 1995) (Denslow et al.). Fish will be fed dechorionated/hatched artemia (E-Z egg) and all exposures will be performed in quadruplicate in tanks containing 6L of water. Exposure solutions will be changed daily at 75% of total volume. Confirmation of exposure concentrations will be performed using an ELISA for E2 (Cayman)(Allinson et al. 2010), as we have done previously (Denslow et al.).

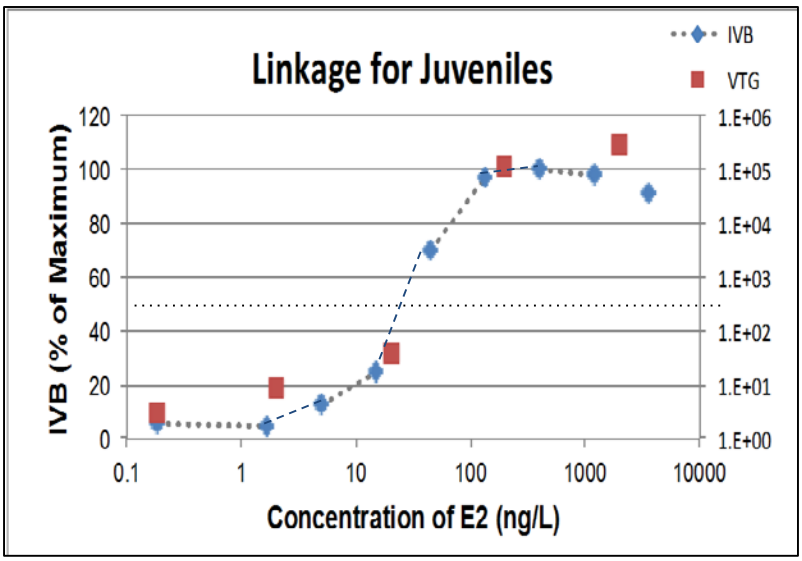

Figure 1. *In vitro* to *in vivo* linkage results from Phase 1. The blue line represents the dose-response curve for the *in vitro* assay, showing an EC_{50} of about 20 ng/L. The red dots represent hepatic Vtg gene expression after 28 days from *in vivo* exposures. The two assays were superimposed on one graph. We are uncertain about the actual relationship of the two graphs. Feminization of fish occurred at concentrations greater than 200 ng E2/L at which point 80% of the fish were female. At 500 ng E2/L, 100% of the fish were female.

From our phase 1 experiment, we know that female *Menidia* differentiate their gonadal tissue in the 35 to 45 dph time frame, while males differentiate their tissues close to 120 dph. Consequently we will treat the juvenile *Menidia* for 28 days, starting with fish that are 30 dph and going to 58 dph, to capture the window for female tissue differentiation. After this time, some of the fish will be sampled and others will be grown in clean water for two months to capture the male gonadal differentiation period. We will take pictures of the fish at the beginning of the experiment, after 14 days, 28 days and at the end of the grow out period to capture growth.

After the 28-day exposure, some of the fish will be sacrificed and livers will be obtained using a dissecting scope. We will prepare hepatic total RNA and measure expression of vitellogenin (Vtg) and choriogenin (Chg), two genes that are known to be under the control of estradiol. We will use at least two housekeeping genes, ribosomal protein L8 (rpL8) and GAPDH.

For histopathology verification of gonadal sex differentiation, we will use cassettes with 4 compartments and capture the gonadal tissue as a sagittal section, using the methods we used in Phase 1 (Denslow et al.).

Task 2: Demonstrate usefulness of assay with environmental samples

This will be a pilot study to show the utility of the *in vitro* assay in San Francisco Bay. We will work closely with staff at SFEI to collect water (1 L) in triplicate and sediments (50 g) in triplicate from 6 locations of varied condition in the Bay. We will provide HLB cartridges and a protocol to SFEI staff for the water collections, which they will put onto the HLB cartridges and mail them along with the triplicate sediment samples from the same location via FEDEX to the Denslow laboratory. We will elute the HLB cartridges with MEOH once we receive them. Sediments will be extracted with acetone using a sonication method we have developed previously (Dang et al. 2016). Extracts will be tested on the Invitrogen ER transactivation assay along with a full 9-point standard curve in both agonist and antagonist mode with the water and sediment extracts to obtain estrogen equivalencies. Each extract will be tested at 4 concentrations, using a binary dilution scheme, following methods we have previously developed (Escher et al. 2014; Maruya et al. 2015; Mehinto et al. 2015).

After examining the *in vitro* results, two concentrations of the extracts that are quantifiable within the linear range of the activity assay will be injected IP into adult male *Menidia* and these will be held for 48 h to confirm changes in hepatic gene expression for Vtg and Chg. We have determined previously that 48 h is sufficient time to see changes in gene expression for these genes in sheepshead minnow, another estuarine fish with approximately the same sensitivity as *Menidia* (Bowman et al. 2000; Denslow et al. 2001). We will also perform histopathology to confirm the sexes of the fish. These experiments will be performed with at least 8 fish per concentration. Livers will be dissected out for total RNA and gonads will be prepared for histopathology.

Expectations and Alternative Strategies. We expect to see very similar *in vitro* and *in vivo* results with *Menidia*, as we have obtained in the Phase 1 study (Denslow et al.), except that we will have enough concentrations to develop an *in vivo* dose response curve. From past experiments, we are confident that these concentrations will impact molecular endpoints within the fish resulting in alteration of gene expression, alterations of gonadal development and growth. Acceptable mortality in the experiments will be <10% for the quadruplicate tanks. The acceptable variance for duplicate determinations of gene expression by Q-PCR will also be 10%.

Task 3: Reporting

We plan to submit a report at the end of year 1. We expect that we will be able to derive relationships between the different levels of results, from the molecular *in vitro* high throughput assays to *in vivo* molecular endpoints and to *in vivo* higher order changes in growth and gonadal tissue differentiation. We expect this demonstration project to show the usefulness of the approach.

Budget

The scope of this study will require one year. We are requesting a total budget of $45,314. This project has already had significant leveraging through the completion of phase 1 of the project. Development of the transactivation assays were originally funded by the State of California Water Board in 2013 ($800,000) and completion of phase 1 of the project required substantial internal funding (on the order of $50,000), in addition to the funds provided by SFEI. We anticipate that this project will take a full year to complete, but have budgeted time very conservatively.

Project Budget

Description	Cost per unit	Total cost
Task 1: ER dose response linkage		
Supplies: in vivo exposure, gene expression by qPCR, histology, E2 dose verification	$10,500	$10,500
Labor -- 2 months	$12,167	$12,167
Task 2: Environmental samples from the Bay		
Supplies for 4 samples in triplicate X 3 = 12 samples -- includes 1 Invitrogen kit/4 samples, fish for IP injection, qPCR, histology, SPE columns	$2,500	$7,500
Labor -- 1 month	$6,084	$6,084
Total direct		$36,251
IDC at 25%		$9,063
Total requested from SFEI		$45,314

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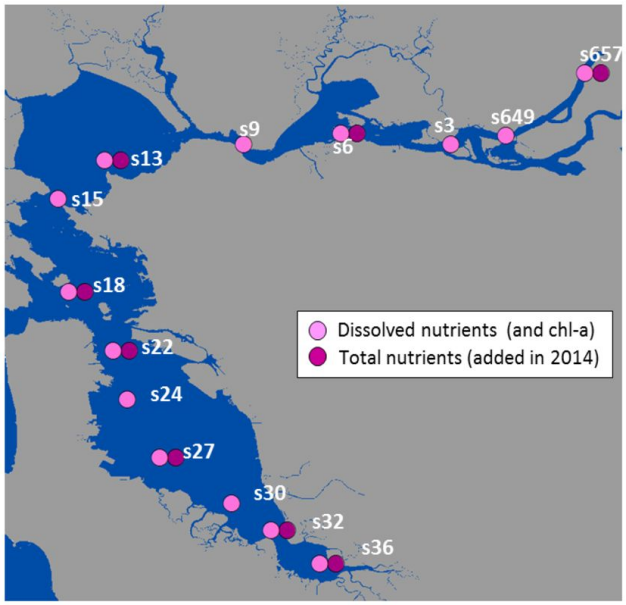
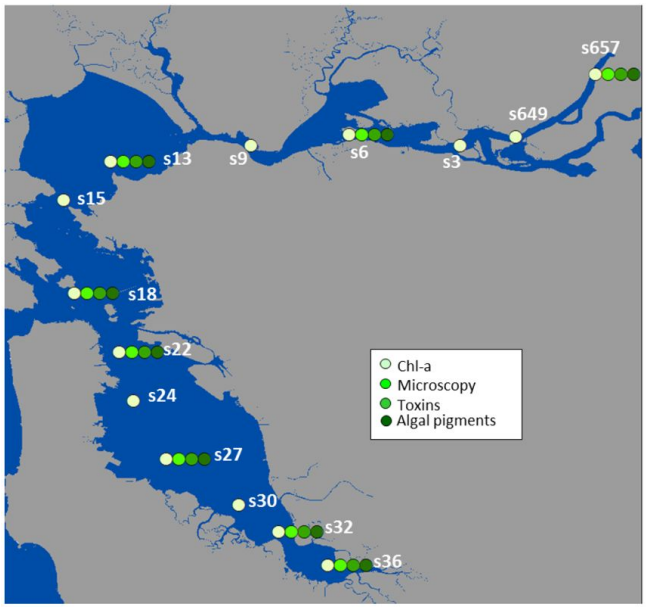
Nutrient Management Strategy Proposals for RMP Funding

C.1 Ship-based sampling and sample analysis
FY17 Estimated NMS Cost = $153,000
Collaborators: USGS, UCSC, SFEI

Ship-based samples will be collected and analyzed for a range of nutrient-related parameters. This data is essential for basic condition assessment, model calibration, and improved understanding of nutrient behavior and nutrient-related effects in the Bay. Ship-based discrete samples will be collected by USGS aboard the R/V Peterson on ~12 full-bay cruises and an additional ~12 South Bay cruises.





Costs covered by NMS

- Nutrient analyses (USGS national lab)
- Analysis of integrated toxin samples (SPATT), discrete toxin samples, and algal pigments (at UCSC)
- Basic data QA/QC and basic reporting
- Additional staff support on cruises to support the collection of NMS-related samples: inorganic nutrients, total nutrients, microscopy, algal pigments, and particulate algal toxins; spatially integrated toxin samples (SPATT)

Costs covered by USGS as part of their core program

- Collection of samples for chlorophyll and ancillary data (e.g., suspended particulate matter, dissolved oxygen, salinity)
- Vertical profiles for multiple parameters
- Underway flowthrough data collection (salinity, T, chl-a fluorescence, turbidity/optical backscatter)
- Program management, scientific oversight
- Data management for USGS parameters plus inorganic nutrients

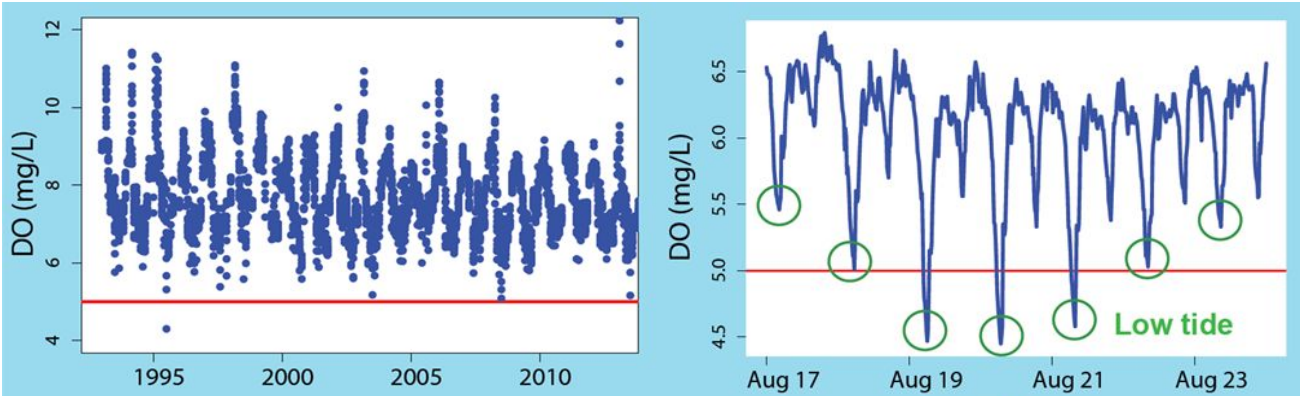
- Ship maintenance, fuel, crew, etc.

Deliverables
Nutrient and chl-a data will be made publicly available through USGS's website. Results will also be summarized in the NMS Annual Report. Data will be used for many NMS aspects (model calibration, condition assessment, assessment framework development).

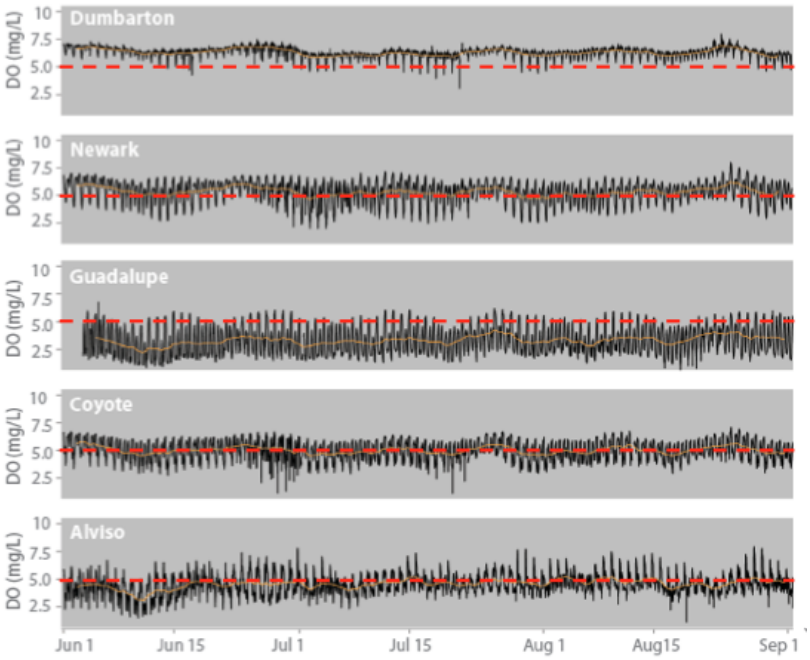
Budget Justification
Nutrient analyses for 300 station-date samples ($40,000; ammonium, nitrate + nitrite, reactive phosphorous, dissolved silicate; total N and P measured at a subset of sites samples); Taxonomy on ~200 samples for phytoplankton community composition and biovolume ($45k); toxin and algal pigment measurements ($55k); Additional staff support for field work ($20k).

C.3 Open-Bay and slough moored sensors: data analysis/interpretation and maintenance
FY17 Estimated NMS Cost = $342,000
Collaborators: SFEI, USGS-Sac, UC Berkeley

While San Francisco Bay is generally not known to be either eutrophic (primary production > 300 g C m^{-2} y^{-1}) or hypoxic (dissolved oxygen < 2 mg L^{-1}), a substantial portion of our knowledge of SFB biogeochemistry comes from a long-term dataset collected in the Bay's main channel. Over the past ~2 decades, dissolved oxygen rarely dipped below 5 mg L^{-1} during biweekly to monthly surveys at stations in South and Lower South Bay (below left). More recently, though, high-frequency moored *in situ* sensors at the Dumbarton Bridge have shown that dissolved oxygen concentrations frequently drop to levels not typically observed in the long time series. For example, dissolved oxygen repeatedly dipped near or below 5 mg L^{-1} in August 2013 during the lower low tide several days in a row (below, right). The DO signal was strongly coupled to the tides at multiple frequencies (semidiurnal: two highs and two lows per day; fortnightly: two spring tides and two neap tides per lunar month), with lowest DO observed around the spring tide on August 20, 2013. Since dissolved oxygen decreases on ebbing tides, we hypothesized that lower dissolved oxygen waters were being advected from margin habitats, including the extensive network of sloughs and creeks in Lower South Bay (SFEI 2015a).



We began testing this hypothesis in Spring/Summer 2015 by installing a network of moored sensors in margin areas of Lower South Bay, measuring dissolved oxygen and a range of other parameters (e.g., salinity, T, turbidity, chl-a fluorescence). Observations over Summer 2015 confirmed that DO frequently fell below 5 mg L^{-1} at multiple sites. The data also indicated that condition varied substantially among the sites, and that DO concentration was strongly influenced by the tides. In addition, DO-related condition at individual sites appears prone to large differences between years, based on comparisons of summer 2012 and 2015 data in Alviso Slough (SFEI 2015a).



Dissolved oxygen concentrations at a subset high-frequency moored sensors sites in Lower South Bay.

FY17 work will focus on the following:

- Complete Year 3 of open bay stations (San Mateo, Dumbarton Bridges) and Alviso Slough.
- Complete Year 1 of slough/creek deployments, and extend through a second summer/fall/winter.
- Data analysis, and quantitative mechanistic interpretations to identify factors contributing to observed conditions.
- Sensor network maintenance.
- Data management and QA/QC.

Deliverables:

- Mid-fiscal year (Dec 2016) update to inform FY18 priorities;
- Summary of major observations in the NMS FY17 Annual Report (e.g., SFEI 2015b), and technical report(s) included as appendices to the annual report describing:
    - Spatial/temporal variability in LSB/South Bay/open Bay and slough water quality (DO, chl, etc.)
    - Mechanistic interpretations, including physical forcings (including exchange between pond ← → sloughs ← → Bay)
    - Initial inferences related to the potential influence of anthropogenic nutrients on DO conditions at specific sites or in LSB margins more broadly, and the potential role of exchange with salt ponds on DO, phytoplankton biomass, and nutrient budgets in LSB.

Budget Justification: 2 staff (0.8 FTE, 0.65 FTE; $233,000) for field work, data management, data analysis, interpretation, and report preparation. Field support and additional technical support (including boat, fuel, field technicians; USGS, $80k); equipment/supplies ($30k, replacement sensors, maintenance).

PCB Strategy: Priority Margin Unit Conceptual Model Development

Oversight group: PCB Workgroup
Proposed by: Jay Davis, SFEI

Proposed Funding

1) Completion of San Leandro Bay Conceptual Model:

($30,000 for this task will be provided as part of a
Supplemental Environmental Project settlement.
No RMP Special Study funds need to be allocated.)

2) Conceptual Model for Priority Margin Unit #3 (Steinberger Slough): $60,000

Proposed Deliverables And Timeline

Deliverable	Due Date
Draft report on San Leandro Bay	Dec 2016
Final report on San Leandro Bay	Mar 2017
Draft report on PMU #3	Apr 2017
Final report on PMU #3	Aug 2017

Summary

The goal of RMP PCB Strategy work over the next few years is to inform the review and possible revision of the PCB TMDL and the reissuance of the Municipal Regional Permit for Stormwater (MRP), both of which are tentatively scheduled to occur in 2020. Conceptual model development for a set of four representative priority margin units will provide a foundation for establishing an effective and efficient monitoring plan to track responses to load reductions and also help guide planning of management actions. The Emeryville Crescent was the first PMU to be studied in 2015-2016. The San Leandro Bay PMU is second (2016-2017). The third PMU will either be Santa Fe Channel/Parr Channel in Richmond Harbor, or Steinberger Slough in San Carlos. A report on this third PMU will be completed in 2017.

Introduction and Background

The RMP PCB Strategy Team formulated a PCB Strategy in 2009. The Team recognized that a wealth of new information had been generated since the PCBs TMDL Staff Report (SFBRWQCB 2008) was prepared. The Strategy articulated management questions

to guide a long-term program of studies to support reduction of PCB impairment in the Bay. The PCB Team recommended two studies to begin addressing these questions. The first recommended study was to take advantage of an opportunity to piggyback on the final year of the three-year prey fish mercury sampling in 2010 to collect data on PCBs in prey fish also. The second study that was recommended was a synthesis and conceptual model update based on the information that had been generated since the writing of the TMDL Staff Report.

The prey fish monitoring revealed extremely high concentrations of PCBs in the food web in several areas on the Bay margins (Greenfield and Allen 2013), and highlighted a need to develop a more detailed conceptual model than the one-box model used as a basis for the TMDL. A model that would support the implementation of actions to reduce loads from small tributaries, a primary focus of the TMDL, would be of particular value. A revised conceptual model was developed that shifted focus from the open Bay to the contaminated areas on the margins where impairment is greatest, where load reductions are being pursued, and where reductions in impairment in response to load reductions would be most apparent (Davis et al. 2014).

The margins appear to be a collection of distinct local food webs that share some general similarities but are largely functionally discrete from each other. Monitoring, forecasting, and management should therefore treat these margin locations as discrete local-scale units. Local-scale actions within a margin unit, or in upstream watersheds, will likely be needed to reduce exposure within that unit. Better characterization of impairment on the margins through more thorough sampling of sediment and biota would help focus attention on the margin units where the need for action is greatest ("priority margin units" or PMUs), and will also provide an important performance measure for load reduction actions taken in local watersheds. Davis et al. (2014) recommended a focus on assessing the effectiveness of small tributary load reduction actions in priority margin units, and provided an initial foundation for these activities.

The 2014 update of the PCB Strategy called for a multi-year effort to implement the recommendations of the PCB Synthesis Report (Davis et al. 2014) pertaining to:

1. identifying margin units that are high priorities for management and monitoring,
2. development of conceptual models and mass budgets for margin units downstream of watersheds where management actions will occur, and
3. monitoring in these units as a performance measure.

A thorough and thoughtful planning effort is warranted given the large expenditures of funding and effort that will be needed to implement management actions to reduce PCB loads from urban stormwater.

Work conducted in 2015 initiated the multi-year PMU effort. The first phase of the 2015 work consisted of a preliminary assessment of margin units downstream of six pilot watersheds that have been prioritized for management actions. In the second phase of the 2015 workplan (implementation of which has continued into 2016), a detailed assessment of one of the four PMUs (Emeryville Crescent) has been developed.

An updated draft of the multi-year plan is presented in Table 1. The goal of RMP PCB special studies over the next few years is to inform the review and possible revision of the PCB TMDL and the reissuance of the Municipal Regional Permit for Stormwater (MRP), both of which are tentatively scheduled to occur in 2020. Conceptual model development for the set of PMUs is the element of the PCB workplan that will have the greatest value in informing the consideration of a revised TMDL and MRP. A conceptual understanding of the anticipated response of these PMUs to load reductions, in addition to providing a foundation for establishing an effective and efficient monitoring plan, will also help guide planning of management actions. As conceptual models are developed for these PMUs, consideration will be given to whether a general model or family of models can be developed that could apply to margin units more broadly. The monitoring plans that are produced will be designed to maximize sensitivity to detecting reduced impairment in the margin units.

Study Objective and Applicable RMP Management Questions

The objectives of this study are:

1. to develop a conceptual understanding of the anticipated response of two PMUs to load reductions, and
2. to develop sensitive monitoring strategies to detect the effectiveness of watershed management actions in reducing PCB impairment in PMUs.

PCB Strategy Questions Addressed

1. What are the rates of recovery of the Bay, its segments, and in-Bay contaminated sites from PCB contamination?
4. Which small tributaries and contaminated margin sites are the highest priorities for cleanup?
5. What management actions have the greatest potential for accelerating recovery or reducing exposure?
6. What are the near-term effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

RMP Management Questions Addressed

4. Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?
   B. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

Study Approach

The multi-year plan for studying PCBs in the margins has three components: conceptual model development, field studies to support/confirm the models, and trend monitoring. The funding requested for 2016 and 2017 would support continued conceptual model development through synthesis and simple modeling based on existing information.

- The revised multi-year plan calls for the development of conceptual models for four PMUs (Emeryville Crescent, Richmond Harbor, Steinberger Slough, and San Leandro Bay) from 2015-2018. Work on this component began for Emeryville Crescent in 2015. Development of a conceptual model for San Leandro Bay was partially funded in 2016. This proposal includes funding for completion of the conceptual model for San Leandro Bay and for a conceptual model for the next PMU (Steinberger Slough).

- To support conceptual model development, a budget for field studies is also included in the multi-year plan. These studies could include, for example, analysis of spatial patterns in surface sediments or of sampling to determine the presence of indicator species and their PCB concentrations. Funding from the RMP Supplemental Environmental Project fund is likely to be available to support field work in San Leandro Bay in 2016. A proposed design for this work will be prepared for PCBWG review if the funding is in.

- According to the multi-year plan, as the conceptual models and preliminary field studies are completed, trend monitoring can be phased in. It is anticipated that this monitoring can begin in San Leandro Bay in 2018 because funding for the preliminary field studies has been identified. The cost will be estimated after the conceptual model is completed.

Given the long-term plan discussed above, the work proposed for 2016 and 2017 is to complete a conceptual site model for a second PMU (San Leandro Bay) and to develop a conceptual site model for a third PMU (Steinberger Slough). The timing of preliminary field studies and trend monitoring will depend on the level of funding for the PCB Strategy.

Tasks for 2016 and 2017

Task 1 (2016): Complete a conceptual site model and first order mass budget for San Leandro Bay
Budget: $30K for SFEI labor to synthesize information and conduct modeling. (These funds will be provided as part of a Supplemental Environmental Project settlement. No RMP Special Study funds need to be allocated.)

Conceptual model development for the second PMU (San Leandro Bay) began in 2016 and will be completed with the funding from this proposal. Additional funding is needed for this task because the original proposal was only partially funded in 2016. The conceptual model will follow the template established for the Emeryville Crescent PMU, with

evaluations of loading, initial deposition, long-term fate, and bioaccumulation. While ideally the site model evaluations will conclude that it is possible to detect reduced concentrations in the Bay, it is also possible that the effort will conclude that this is not feasible with a realistic effort given the relative magnitude of the reduced loading, the reservoir of PCBs already in the PMU, and environmental variation.

Timing and Deliverables:

- A draft technical report documenting a conceptual site model and monitoring plans for San Leandro Bay by December 2016. Final report in Mar 2017.

Task 2 (2017): Complete a conceptual site model and first order mass budget for Steinberger Slough

Budget: $60K for SFEI labor to synthesize information and conduct modeling.

The approach will be the same as that described under task 1.

Timing and Deliverables:

- A draft technical report documenting a conceptual site model and monitoring plans for Steinberger Slough by April 2017. Final report in Aug 2017.

References

Davis, J.A., L.J. McKee, T. Jabusch, D. Yee, and J.R.M. Ross. 2014. PCBs in San Francisco Bay: Assessment of the Current State of Knowledge and Priority Information Gaps. RMP Contribution No. 727. San Francisco Estuary Institute, Richmond, California.

Table 1. PCB studies and monitoring in the RMP from 2010 to 2019. Numbers indicate budget allocations in $1000s. Numbers in parentheses are expected funds from the RMP Supplemental Environmental Project fund.

Element	PCB Questions Addressed	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food Web Uptake (Small Fish)	1, 4	50									
PCB Conceptual Model Update	1,2,3,4,5,6		53								
Development and updating of multi-year workplan and continued support of PCB Workgroup meetings							10	10	10	10	10
Prioritize Margin Units	1, 4, 5, 6						30				
Develop Conceptual Site Models and Mass Balances for PMUs (4 PMUs)	1, 4, 5, 6						45	30 (30)	60	60	
PMU Field Studies to Support Development of Conceptual Site Models and Monitoring Plans	1, 4, 5, 6							(52)	TBD	TBD	TBD
PMU Trend Monitoring (5 PMUs)	1, 4, 5, 6									TBD	TBD
RMP Total		50	53				85	40	TBD	TBD	TBD
SEP Funding								82			
Overall Total									TBD		

PCB Strategy: PCB Strategy Coordination and Technical Support

Oversight group: PCB Workgroup
Proposed by: Jay Davis, SFEI

Proposed Funding: $10,000

Proposed Deliverables And Timeline

Deliverable	Due Date
Updated PCB Multi-Year Plan	Jun 2017

Introduction and Background

The RMP PCB Strategy Team formulated a PCB Strategy in 2009. The Team recognized that a wealth of new information had been generated since the PCBs TMDL Staff Report (SFBRWQCB 2008) was prepared. The Strategy articulated management questions to guide a long-term program of studies to support reduction of PCB impairment in the Bay.

The 2014 update of the PCB Strategy called for a multi-year effort to implement the recommendations of the PCB Synthesis Report (Davis et al. 2014) pertaining to:

1. identifying margin units that are high priorities for management and monitoring,
2. development of conceptual models and mass budgets for margin units downstream of watersheds where management actions will occur, and
3. monitoring in these units as a performance measure.

A thorough and thoughtful planning effort is warranted given the large expenditures of funding and effort that will be needed to implement management actions to reduce PCB loads from urban stormwater. The goal of RMP PCB Strategy work over the next few years is to inform the review and possible revision of the PCB TMDL and the reissuance of the Municipal Regional Permit for Stormwater (MRP), both of which are tentatively scheduled to occur in 2020.

The multi-year plan for studying PCBs in the margins has three components: conceptual model development, field studies to support/confirm the models, and initiation of trend monitoring. Conceptual model development for a set of four representative priority margin units will provide a foundation for establishing an effective and efficient monitoring plan to track responses to load reductions and also help guide planning of management actions. Preliminary field studies and trend monitoring will be phased in as the level of funding for the PCB Strategy allows.

Study Objective and Applicable RMP Management Questions

The objective of this task is to provide coordination and technical support for continuing development of the PCB Strategy. This task would therefore address all of the questions articulated in the Strategy.

1. What are the rates of recovery of the Bay, its segments, and in-Bay contaminated sites from PCB contamination?
2. What are the present loads and long-term trends in loading from each of the major pathways?
3. What role do in-Bay contaminated sites play in segment-scale recovery rates?
4. Which small tributaries and contaminated margin sites are the highest priorities for cleanup?
5. What management actions have the greatest potential for accelerating recovery or reducing exposure?
6. What are the near-term effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

The task would also address many of the overarching RMP management questions.

Tasks for 2017

Consult with PCB Workgroup and update multi-year plan in support of the TMDL ($10K)

Funds for this task would enable SFEI to continue to consult with the PCB Workgroup and the Small Tributary Loadings Strategy Team regarding plans for the next iteration of the TMDL and RMP activities that can inform the TMDL. Funds would also support small-scale synthesis of information that is needed to support these discussions. The plan will include a multi-year schedule of budgets and deliverables aimed at providing a technical foundation for the next iteration of the TMDL.

Timing and Deliverables: An updated PCB multi-year plan in June 2017. The plan will include a multi-year plan schedule of budgets and deliverables.

Special Study Proposal: Sturgeon Derby - Correlation of Selenium in Sturgeon Tissues

Summary: In March 2016, the State Water Resources Control Board approved a Selenium TMDL for North San Francisco Bay, which established a white sturgeon muscle tissue target of 11.3 ug/g dry weight as the basis for evaluating impairment. In 2015 and 2016, the RMP funded a study in collaboration with USFWS and Stantec, Inc. to collect tissue samples from angler-harvested female sturgeon collected as part of the annual Sturgeon Derby held out of Bay Point. The objective of this study was to establish relationships between selenium concentrations measured in non-lethally collected tissues (muscle plugs, fin rays) and those that are more closely tied to, or predictive of, adverse impacts in white sturgeon due to selenium (ovaries, otoliths). This study proposes a continuation of this sampling in 2017.

Estimated Cost: $42,000

Oversight Group: RMP Selenium Workgroup

Proposed by: Jennifer Sun and Jay Davis

Background

Since 1998, San Francisco Bay has been identified as impaired by selenium under the Clean Water Act. In April 2014, the RMP formed a Selenium Workgroup to evaluate information needs that can be addressed by the Program in the next several years. The charge given to the workgroup by the RMP Steering Committee was to focus on low-cost, near-term monitoring elements that can provide information that provides high value in support of policy development and decision-making.

In 2016, the State Water Resources Control Board approved a selenium TMDL for North San Francisco Bay. The TMDL established a target concentration of 11.3 ug/g dw in white sturgeon muscle tissue as the basis for evaluating impairment (Baginska 2015). In order to help implement this regulation, the Selenium Workgroup has recently focused on developing non-lethal monitoring methods that will allow for the routine collection of large numbers of white sturgeon muscle tissue samples.

Sampling sturgeon ovaries, although logistically more challenging than sampling using non-lethal methods, would provide a more direct metric of the risk to sturgeon reproduction. USEPA recently published draft selenium criteria for freshwater that highlight egg or ovary data as the preferred endpoint most directly tied to adverse effects (USEPA 2015). Data that would allow evaluation of the correlation between concentrations measured in non-lethally collected tissues and ovary concentrations would enhance the application of muscle plugs as an impairment indicator.

The RMP is currently working to establish two non-lethal sampling methods for measuring selenium concentrations in sturgeon tissues. During the 2009 and 2014 RMP sport fish sampling events, paired muscle plug and muscle fillet samples were analyzed for selenium to determine if muscle plugs could be used as surrogates for the more common measurement of muscle tissue – muscle fillets. Selenium concentrations in muscle plugs were found to correlate well with concentrations in muscle fillets for the 24 fish sampled. In 2016, paired muscle plug and muscle fillets were analyzed from nine female sturgeon collected during the Sturgeon Derby, and were also found to be significantly and positively correlated. The RMP has also further developed the muscle plug collection technique on live sturgeon in collaboration with the California Department of Fish and Wildlife (CDFW), during the 2014 and 2015 Selenium in White Sturgeon Muscle Plugs special studies (Sun et al. 2016, DuBois & Harris 2015).

As part of the 2015 and 2016 Sturgeon Derby studies, the RMP also collaborated with Dr. Vince Palace, currently with the International Institute of Sustainable Development (IISD) (formerly with Stantec, Inc.), and Dr. Norman Halden with the University of Manitoba, Department of Geological Sciences, to test a second non-lethal sampling method using fin rays using data collected at the annual Sturgeon Derby. In this Sturgeon Derby, held on Super Bowl weekend, anglers attempt to catch sturgeon that come closest to a selected size. Fish that are close to the target size are brought to a central location and sacrificed. For the past several years, the USFWS has collected tissues from these sturgeon and analyzed them for a suite of metals and organics, including selenium, in gonads (including ovaries), liver, and plasma. These data have not yet been published. During the 2015 and 2016 Sturgeon Derbies, the RMP successfully collaborated with USFWS and Dr. Palace to collect fin ray and otolith samples for selenium analysis, for comparison with concentrations measured in muscle plugs, ovaries, and other tissues.

Fin rays are taken as a clip and are easy to collect by non-specialists, and fin clips have been shown to be non-harmful to sturgeon (Collins and Smith 1996). Because fin rays have a regular growth pattern similar to growth rings of a tree, a laser ablation MS technique (laser ablation inductively coupled plasma mass spectrometry [LA-ICP-MS]) can be used to allow for the analysis of concentrations of selenium and other elements in each annual ring (i.e., concentrations in the fish tissue over the time). Data showing trends in selenium concentrations in North San Francisco Bay white sturgeon tissue over time will help elucidate the dynamic selenium bioaccumulation patterns in sturgeon, and begin to answer the question of whether or not changes in selenium water chemistry and prey over time relates to changes in tissue concentrations in sturgeon.

A recent study found that fish otolith selenium measurements are the best predictors of ovary selenium, enhancing data collected from tissues alone (Reash, Friedrich, and Halden 2014). However, otoliths can only be collected from sacrificed fish. Thus, fin ray analysis is being developed as a potential alternative to both muscle plug and otolith sampling. The research team is currently using otolith microchemistry analyses to establish the chemical stability of fin ray samples. Fin ray data will also be compared with muscle and ovary data to develop a model that establishes the relationship between selenium concentrations in these tissues.

During the 2016 Derby, endolymph samples were also collected for selenium analysis by Dr. Fei Wang at the University of Manitoba. Understanding selenium concentrations in the endolymph, or the fluid in which otoliths are suspended, will contribute to a more complete model of selenium partitioning from the blood plasma to the endolymph to the otoliths, which will then be compared to selenium in the fin rays.

The annual sturgeon fishing tournament in the Delta again provides an opportunity to obtain tissue samples from a small number of female sturgeon in 2017. These samples will be used to test the relationships between selenium concentrations measured in tissues collected using lethal (ie. ovaries) and non-lethal (ie. muscle plugs, fin rays) methods, and contribute the development of the fin ray microchemistry analysis technique.

In both 2015 and 2016, just under 30 fish were sacrificed during the Derby, including 8 females in 2015 and 9 females in 2016. Because sampling conditions and sex ratios may be unpredictable, the proposed target number of female fish sampled during the 2017 Sturgeon Derby will remain at 15.

This proposal is requesting funds for a third year of sampling at the sturgeon Derby in 2017, which will include measuring selenium in muscle plugs, ovaries, fin rays, otoliths, and endolymph. The continuation of endolymph selenium analysis in 2017 will be reviewed by the Selenium Workgroup following the analysis of data from the 2016 Derby samples.

Study Objectives and Applicable RMP Management Questions

The primary objectives of this monitoring element are to:

1. Develop methods for non-lethal white sturgeon tissue sample collection and selenium analysis, including muscle plug and fin ray sampling techniques; and
2. Evaluate the relationship between tissues that can be monitored non-lethally (muscle plug or fin rays) and tissues that are more directly tied to adverse reproductive effects (ovary and eggs); and
3. Track temporal trends in selenium impairment over time

This study addresses key questions identified by the Selenium Strategy and RMP (Table 1).

Selenium Strategy questions addressed:

2. Are the beneficial uses of San Francisco Bay impaired by selenium?
4. How do selenium concentrations and loadings change over time?

Table 1. Study objectives and questions relevant to RMP management questions.

Management Question	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely? 1B. What potential for impacts on humans and aquatic life exists due to contaminants in the Estuary ecosystem?	Compare measured concentrations to toxicity and regulatory thresholds (North Bay Selenium TMDL, USEPA site-specific criteria).	Do the data indicate a need for management actions? What factors are influencing the observed selenium concentrations? How should the TMDL muscle tissue target be assessed?
2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?		
3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?		
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.B. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?	Compare measured concentrations to plug and fillet concentrations measured during past studies, including past iterations of this study.	Are selenium concentrations increasing or decreasing? What factors may be influencing these trends?
5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?		

Approach

This study would be performed in collaboration with IISD. IISD would perform the collection of tissue samples from female fish caught at the Derby, and conduct selenium microchemistry analyses on the fin rays and otoliths. Analyses of selenium in endolymph will be conducted by the University of Manitoba. RMP staff would plan the study, assist with tissue sample collection, manage the data, and write a brief

technical report. The Moss Landing Marine Laboratory, Marine Pollutions Studies Lab (MLML-MPSL) or a comparable laboratory would perform selenium analyses on ovaries and muscle plugs, and subsequently prepare and ship these samples to UC Davis to perform C, N, and S stable isotope analyses. The stable isotopes will provide information on diet and habitat use by the sturgeon.

Tissues would be collected and analyzed from up to 15 female white sturgeon. If fewer than 15 females are euthanized during the Derby, tissues would be collected from all females. If samples are collected from fewer than 15 females, the remaining analytical budget will be used to analyze selenium in the muscle fillets of female fish. The sampling would occur on Super Bowl weekend in 2017.

Budget
The proposed budget for this Special Study is $42,000.

Table 2. Budget for the 2017 Sturgeon Derby Proposal

Task	Estimated Cost
Labor*	
Project Planning & Coordination	$4,000
Field Work	$3,800
Data Management	$7,800
Reporting	$7,000
Subtotal	**$22,600**
Subcontracts	
MLML-MPSL – 15 Se analyses (muscle plugs) @ $222/sample	$3,330
MLML-MPSL – 15 Se analyses and sample homogenization (ovaries) @ $327/sample	$4,905
UCD - 15 C, N, S analyses (muscle plugs) @ $25/sample	$375
IISD- Travel ($3,000), instrument set-up ($2,500), 15 fin ray and 15 otolith selenium microchemistry analyses @ 115/sample	$8,950
University of Manitoba – 15 Se analyses (endolymph) @ $60/sample	$900
Subtotal	**$18,460**
Direct Costs	
Equipment - biopsy plugs, sample containers, etc.	$390
Shipping	$200
Travel - 2 days of travel for 2 RMP staff	$350
Subtotal	**$940**
Grand Total	$42,000

*Project management, contract management, and archiving costs will be included in the RMP base funding

Reporting

A draft technical report describing the results of the study will be prepared by September 30, 2017. The technical report will be reviewed by the Selenium Workgroup and the TRC and will be finalized by December 31, 2017.

References

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Selenium Monitoring Workshop Followup

Oversight group: Selenium Workgroup
Proposed by: Jay Davis, SFEI

Funding requested for 2017: $20,000

Description

At their May 2016 meeting, the Selenium Workgroup, at the request of the Water Board, discussed the need to develop a technical consensus on a robust suite of trend indicators of selenium impairment in the North Bay. The goal is to identify leading indicators of change to allow prompt management response to signs of increasing impairment. Of particular concern are the possible impacts of changes in hydrology in the Delta or changes in selenium loads to Bay-Delta tributaries in the Central Valley. A technical workshop on this topic will be convened this summer. This funding request is a placeholder that will allow for followup activities stemming from the workshop. The funds could be used for additional planning or to augment existing monitoring to address high priority information needs.

Selenium Strategy Coordination and Technical Support

Oversight group: Selenium Workgroup
Proposed by: Jay Davis, SFEI

Funding requested for 2017: $10,000

Introduction and Background

In April 2014 the RMP formed a Selenium Strategy Team to evaluate information needs that can be addressed by the Program in the next several years. The charge given to the Team by the RMP Steering Committee was to focus on low-cost, near-term monitoring elements that could provide information that provides high value in support of policy development and decision-making. A TMDL for the North Bay has been developed and approved by the Regional Water Board and the State Water Board, and is awaiting approval by USEPA. Development of a TMDL for the South Bay will be considered after the North Bay TMDL is completed. The need for greater investment in studies in support of managing selenium in the Bay is currently being considered by the Workgroup.

Study Objective and Applicable RMP Management Questions

The objective of this task is to provide coordination and technical support for continuing development of the Selenium Strategy. This task would therefore address all of the questions currently articulated in the Strategy (an update of these questions is in progress).

1. What are appropriate thresholds?
2. Are the beneficial uses of San Francisco Bay impaired by selenium?
3. What is the spatial pattern of selenium impairment?
4. How do selenium concentrations and loadings change over time?
5. What is the relative contribution of each loading pathway as a source of selenium impairment in the Bay?

The task would also address many of the overarching RMP management questions.

Tasks for 2017

Funds for this task would enable SFEI to continue to convene the Selenium Workgroup to allow discussions of plans for studies in support of implementation of the North Bay TMDL and the consideration of a TMDL for South Bay, to develop RMP workplans to support these efforts, and for any small-scale synthesis of information that is needed to support these discussions. The plan will include a multi-year schedule of budgets and deliverables aimed at providing a technical foundation for the TMDLs.

Timing and Deliverables

An updated selenium multi-year plan will be prepared for June 2017. The plan will include a multi-year schedule of budgets and deliverables.

Special Study Proposal: Small Tributaries Loading Regional Watershed Spreadsheet Model

Summary: The goal of the Small Tributaries Loadings Strategy (STLS) Program over the next few years is to continue to provide information to RMP Stakeholders and the public that directly supports the identification and management of PCBs and Hg sources, concentrations, loads, and the determination of trends in relation to management efforts and beneficial uses in San Francisco Bay. To support improved estimates of regional scale watershed loads, the outcome of this proposal will be a GIS map of watershed scale loads for the region estimated from the RWSM that will be calibrated or verified with a minimum of 60 sites now characterized for of PCBs and Hg concentrations[1]. The information generated from this model, including updated land use specific yields, will also be useful for assisting BASMAA program staff at smaller scales with their proposed effectiveness evaluation methods for stormwater BMPs.

Estimated Cost: Option 1: $40,000
Oversight Group: STLS/SPLWG
Proposed by: Jing Wu, Lester McKee, Alicia Gilbreath (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Task	Deliverable	Due date															
		2016				2017											
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
A	Finalize work plan based on latest info. and priorities		!!														
B	Compile latest data (GIS & stormwater data)	!		!													
C	Recalibrate model, estimate loads, & update model report	!		!!		!		!!	!	!!							

[MQ] = Management Questions given in Provision C.8.f. of the Municipal Regional Stormwater Permit (MRP 2.0)
! = STLS check in for review and course corrections
!! = SPLWG oversight and review

Background

The San Francisco Bay Hg and PCBs TMDLs call for a reduction in loads by 50 and 90% by 2028 and 2030, respectively. In response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) called for a range of actions including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of loads of sediments and trace contaminants on a watershed basis and at a regional scale, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing water quality impairment. These same needs were reflected in the small tributary loading strategy (STLS) (SFEI, 2009). On November 19, 2015, the second MRP was issued and provided an updated set of management questions (provided below) (SFRWQCB, 2015).

The development of the Regional Watershed Spreadsheet Model (RWSM) was recommended in the Strategy to support improved estimates of regional scale loads (primarily), to provide a quantification of the relative concentrations and loads between watersheds to help focus management, and possibly to help identify areas within watersheds for further investigation as part of the weight of evidence approach. Starting in 2010, a multi-year effort was undertaken to systematically develop and calibrate the Model. The development process has been documented through four previous progress reports. The Model was structured to use either a hydrology model or suspended sediment (SS) model as the basis for the

[1] Data were also collected by the Santa Clara and San Mateo Stormwater programs using the watershed characterization reconnaissance study design. This data should be made available in later fall for comparison to the RMP data during the reporting phase of the project.

pollutant models. The modeling effort also included linkages to other efforts by Bay Area Stormwater Management Agencies Association (BASMAA) and the RMP. Milestones achieved to date include:

- Developing and calibrating the hydrology model and the completion of pollutant profiles for PCBs, Hg, SS, Cu, Se, OC pesticides, and PBDEs (Lent and McKee, 2011; Lent et al., 2012),
- Improving GIS data about the sources of PCBs and Hg (McKee et al., 2014; Wu et al., in SPLWG review), and
- Improving the model calibration procedure to include analysis of modeling errors and output of the first reasonable model calibrations for PCBs (Wu et al., in SPLWG review).

Additional improvements to the model are being made during 2016 using the RWSM model development funding ($35,000) that was approved in the 2016 budget. The work plan for the 2016 funding includes:

1. Further refinement of the GIS layers including exploring land use and source area anomalies in watersheds that are currently poorly calibrated,
2. Exploration of improved model parameterization,
3. Exploration of the calibration data to remove outliers and development of a method to estimate variability associated with composite data,
4. Further refinement of the calibration procedures including possible exploration of:
    a. Calibrating to a larger group of watersheds (41 now available rather than 22)
    b. Calibrating to the loads data set rather than to concentrations
    c. Hybrid calibration (iterative auto and manual calibration)
    d. Other recommendations by our advisors

Study Objectives and Applicable RMP Management Questions

The main study objectives are three fold:

1. Determine regional scale loads of PCBs and Hg
2. Determine which individual watersheds may be producing disproportionally high loads per unit watershed area and then rank and separate these from lower yielding watersheds
3. Perform model runs to provide information on loading coefficients or loads at user requests, such as providing updated land use based yields or fine scale GIS information to BASMAA to support their proposed effectiveness evaluation methods for stormwater BMPs and treatment retrofit.

These objectives address management question (MQ) 4 primarily but also supports MQ1 by providing a quantified load rankings by watershed, MQ2 by its use for estimating loading to priority margin units, and MQ 3 by providing a maps of concentrations and loads Bay Area wide as a basis to support effectiveness evaluation methods for stormwater BMPs. While the STLS Trends Strategy has a management question that includes forecast modeling, it has not yet been determined which modeling platform would be most suitable. During the model calibration process, watersheds that do not calibrate well are further investigated virtually to try to understand land use or source area anomalies - a part of the calibration process that directly links to MQ1.

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5: Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

By mid-2016, it is anticipated that an improved calibration of the PCB and mercury model will be completed based on data from about 41 calibration watersheds. Pending the outcomes of the 2016 work plan, STLS and the SPLWG will be consulted to agree upon and recommend a work plan for 2017. The goal of the additional work will be to get the PCB and Hg models sufficiently calibrated to meet the needs of BASMAA and other partners. The menu of options that will be considered to achieve this goal includes:

1. Recalibration of the hydrology model
2. Further (slight) improvements to the parameterization
3. Recalibration of the PCB and Hg models using data from 60+ watersheds (additional data collected by the RMP during WY 2016 and possibly data collected by the Santa Clara and San Mateo Stormwater programs using the RMP watershed characterization reconnaissance study methodology)
4. Response to user requests; for example in relation to effectiveness evaluation of stormwater BMPs
5. Completion of a user manual and full model documentation

Reporting

A summary of the model updates, the results of the model calibration, and the regional loads will be presented in a technical report (draft in March 2017, final in June 2017).

Linkages to other RMP Workgroups

The RWSM is being used to estimate the loads to the Priority Margin Units (PCB WG).

References

Lent, M.A. and McKee, L.J., 2011. Development of regional suspended sediment and pollutant load estimates for San Francisco Bay Area tributaries using the regional watershed spreadsheet model (RWSM): Year 1 progress report. A technical report for the Regional Monitoring Program for Water Quality, Small Tributaries Loading Strategy (STLS). Contribution No. 666. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/sites/default/files/RWSM_EMC_Year1_report_FINAL.pdf

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Special Study Proposal: Small Tributaries POC Loading Program Management

Summary: The goal of the Small Tributaries Loadings Strategy (STLS) Program over the next few years is to continue to provide information to RMP Stakeholders and the public that directly supports the identification and management of PCBs and Hg sources, concentrations, loads, and the determination of trends in relation to management efforts and beneficial uses in San Francisco Bay. To support the Small Tributaries POC stormwater concentration and loading program, the outcome of this task will be to maintain monthly communication with BASMAA program and Water Board representatives. This will be completed through regular check in phone calls, planning for and development of meeting agendas and materials, preparation of meeting summaries, and monitoring the agenda of and attendance at key external meetings.

Estimated Cost: Option 1: $30,000
Oversight Group: STLS/SPLWG
Proposed by: Lester McKee, Alicia Gilbreath, Jennifer Hunt (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Task	Deliverable	2017										
		J	F	M	A	M	J	J	A	S	O	N	D
A	STLS Management	!	!	!	!	!!	!	!	!	!	!	!	!

! = STLS check in for review and course corrections
!! = STLS/SPLWG oversight and review

Background

The San Francisco Bay Hg and PCBs TMDLs call for a reduction in loads by 50 and 90% by 2028 and 2030, respectively. In response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) called for a range of actions including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of loads of sediments and trace contaminants on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. These same needs were reflected in the small tributary loading strategy (STLS) (SFEI, 2009). On November 19, 2015 the second MRP was issued and provided an updated set of management questions (provided below) (SFRWQCB, 2015).

Study Objectives and Applicable RMP Management Questions

With an increased focus on collaboration synergy between projects funded by the RMP and those funded directly by BASMAA, it was recognized back in 2009 that an annual budget allocation was needed to ensure constant and efficient communication between RMP program staff and BASMAA and Water Board representatives. These objectives help to ensure quality planning and implementation of projects that aim to answer the following five management questions:

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?

MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5: Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

RMP staff will provide management of the STLS process and STLS projects. Tasks include:

- Monthly meetings (phone calls)
- Quarterly or as needed face-to-face meetings
- Planning for and development of meeting agendas and materials
- Preparation of meeting summaries, and
- Monitoring the agendas of, and attendance at key external meetings (e.g. BASMAA Monitoring / POC Committee meeting, BASMAA BoD meetings)

Reporting

Written meeting summaries are prepared during and after every meeting and archived. A list of action items and due dates are also maintained.

Linkages to other RMP Workgroups

RMP staff aim to help transfer information between other RMP workgroups and committees and the STLS and SPLWG. These include meetings of the Priority Margin Units (PCB Workgroup) and the Emerging Contaminants Workgroup (ECWG).

References

SFEI, 2009. RMP Small Tributaries Loading Strategy. A report prepared by the strategy team (L McKee, A Feng, C Sommers, R Looker) for the Regional Monitoring Program for Water Quality. SFEI Contribution #585. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/sites/default/files/biblio_files/Small_Tributary_Loading_Strategy_FINAL.pdf

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Special Study Proposal: Small Tributaries Loading POC Trends Strategy and Trends Monitoring

Summary: The goal of the Small Tributaries Loading Strategy (STLS) Program over the next few years is to continue to provide information to RMP Stakeholders and the public that directly supports the identification and management of PCBs and Hg sources, concentrations, and loads, and the determination of trends in relation to management efforts and beneficial uses impacts in San Francisco Bay. To support stormwater concentration and loading trends evaluation, the outcomes of this proposal will be provision of an improved dataset (more samples targeted at improving the description of source, release, and transport processes at selected tributary monitoring sites) following the monitoring design laid out at the conclusion of the 2016 Trends Strategy workplan, data evaluation to prepare refine the monitoring plan for subsequent winter seasons (i.e., 2018 and 2019), and further evaluation of data and information to continue the dialogue on the ultimate design of a long-term monitoring program for trends.

Estimated Cost: Option 1: $100,000; Option 2: $200,000
Oversight Group: STLS/SPLWG
Proposed by: Lester McKee, Alicia Gilbreath, Jennifer Hunt (SFEI)

Background

The San Francisco Bay Hg and PCBs TMDLs call for reductions in loads by 50% and 90% by 2028 and 2030, respectively. In response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) called for a range of actions including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of loads of sediments and trace contaminants on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. These same needs were reflected in the Small Tributary Loading Strategy (STLS) (SFEI, 2009). On November 19, 2015 the second MRP was issued and provided an updated set of management questions (provided below) (SFRWQCB, 2015). With an increased focus on finding tributaries and sources with disproportionally high concentrations and loads of PCBs and Hg, and the transition from the pilot testing phase of BMP selection to focused implementation, it was recognized that a Strategy for monitoring trends was needed for stormwater concentrations and loads, connecting management effort on land with water quality improvements in the Bay.

During 2015, the RMP funded the first phase of developing the Small Tributaries Loading Strategy-Trends Strategy (STLS-T). Beginning in July 2015 and continuing through April 2016, a series of five STLS-T meetings occurred that resulted in the development of a series of interim products including a refined trends strategy workplan, a mission statement, the development of three key trends strategy management questions, a list of potential stormwater quality indicators, a number of conceptual models including a conceptual model of how those indicators relate to watershed scale, selection of the indicators and scales on which to focus initial power analysis efforts, collation of available data, and development and implementation of a power analysis work plan. In April 2016 the first draft of the STLS-T strategy document was prepared ready for the STLS team review along with the results of the power analysis.

The draft power analysis indicated the following general preliminary results. In relatively “clean” watersheds which exhibit relatively low concentration variability, >80% power to detect a continually declining trend of just 25% over 25 years with 95% confidence is possible with just 2 samples every 4 years or 5 samples every 5 years. However, the interest and focus is more on watersheds that currently exhibit greater leverage for improvement (disproportionally higher concentrations, particle ratios and

pollutant loads relative to their watershed area, usually with a history of older urban and industrial land use). For these types of watersheds, the preliminary results of the power analysis suggest that to obtain 80% power, at least 15 samples every three years (equivalent to 5 annually, or 8 biennially) would be needed to see a continual 90% decline over a 25 year period.

To increase the power to detect trends, a number of data stratification exercises were evaluated including removing base flow samples, stratifying for early versus late season (based on season-to-date rainfall less than or greater than 50% mean annual rainfall for each unique sampling site), and rising and falling stage (before and after peak storm flow for each unique storm at each unique site). The results of this analysis along with graphical inspection of scatter plots of flow versus concentration and particles ratios led to the conclusion that the current baseline data are insufficient to provide high enough sample numbers for some strata and, that overall, for several of the more polluted sites (Sunnyvale East Channel watershed and Pulgas Creek Pump Station watershed), the existing baseline data do not fully describe all the underlying source-release-transport processes.

External peer review of the power analysis and strategy occurred in June 2016. The primary recommendations from the peer reviewers included:

- Additional exploration of the existing dataset to determine if there are other explanatory factors or statistical models that would be helpful in designing a short and long-term trends strategy monitoring program.
- Additional data are needed from long term monitoring sites to augment the existing dataset. The primary recommendation was to "oversample" at one or two long-term monitoring sites.

Study Objectives and Applicable RMP Management Questions

The main study objectives are three fold:

1. Develop and implement a sampling program to provide suitable baseline data to support the final design of a monitoring program to identify trends in concentrations and loads over appropriate spatial and temporal scales, connecting management effort on land with water quality improvements in the Bay
2. Complete further data evaluation to adjust the monitoring plan for subsequent monitoring seasons (i.e., 2018 and 2019), and
3. Further evaluation of data and information to continue the dialogue on the ultimate design of a long term monitoring program for trends.

The proposed Trends Strategy work plan will directly address management question (MQ5), but will also provide improved data for calibration of the Regional Watershed Spreadsheet Model (RWSM) (MQ4), and to a lesser extent, provide information that might help us to continue to evaluate the nature of sources in the watersheds selected for monitoring (MQ1) and the impacts to areas on the Bay Margin downstream (MQ2) especially if the selected watersheds are drain to a priority margin unit (PMU).

MRP 2.0 Q1:	Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2:	Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3:	Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4:	Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5:	Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

A draft workplan to implement the recommendations of the peer reviewers was developed subsequent to the peer review meeting. The estimated budget for this workplan is $270,700 (see table below). The likely available funding is $163,500, consisting of $63,500 of remaining RMP 2016 funds and assuming $100,000 of RMP 2017 funds as recommended by the TRC. Since the proposed project budget exceeds available funds, RMP staff will work with the STLS workgroup to review the workplan and prioritize workplan components. The workplan, as currently designed, includes:

1. Additional data exploration.
2. Design the WY 2017 trends monitoring plan.
3. WY 2017 trends monitoring, data management, data analysis, and reporting.
4. A follow-up peer-review meeting to discuss findings and next steps for the trends strategy.
5. Develop a final trends sampling and analysis plan.

Work products	**Budget**
Additional data exploration	$ 55,000
Develop WY17 Sampling Plan	$ 5,000
Monitoring and laboratory analysis-5 storm events, remote sampler deployment at one site for 2 months	$ 90,000
Data management	$ 23,700
Draft field data analysis and interpretation including new power analysis; brief tech memo	$ 50,000
Peer-review meeting	$ 10,000
Travel for peer reviewers (WY17 results)	$ 5,000
Trends strategy update	$ 7,000
Travel for peer reviewers (WY18 sampling plan)	$ 5,000
Final sampling and analysis plan	$ 10,000
Contingency	$ 10,000
Total Cost	$ 270,700
Likely Budget	$ 163,500
Budget Deficit	$ 107,200

Reporting

The reporting deliverable will be determined by the STLS workgroup.

Linkages to Other RMP Strategies

Some of the sampling sites may be selected in the watersheds of the Priority Margin Units (PCBWG) or monitored for emerging contaminants with funding from the ECWG.

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Special Study Proposal: Small Tributaries Loading POC Watershed Characterization Reconnaissance Monitoring

Summary: The goal of the Small Tributaries Loadings Strategy (STLS) Program over the next few years is to continue to provide information to RMP Stakeholders and the public that directly supports the identification and management of PCBs and Hg sources, concentrations, loads, and the determination of trends in relation to management efforts and beneficial uses in San Francisco Bay. To support a weight-of evidence approach for the identification and management of PCBs and Hg sources, the outcome of this proposal will be further knowledge about concentrations and particle ratios in stormwater in areas that have a historically and disproportionally larger area of older urban and industrial land use.

Estimated Cost: Option 1: $200k
Oversight Group: STLS/SPLWG
Proposed by: Lester McKee, Jennifer Hunt, Alicia Gilbreath, Jing Wu, and Don Yee (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Task	Deliverable	Due date																		
		2016				2017												2018		
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
A	Site selection	!																		
B	Wet season monitoring		!	!		!		!	!											
C	QA & Data Management									!!										
D	Interpretation & reporting															!				!!

[MQ] = Management Questions given in Provision C.8.f. of the Municipal Regional Stormwater Permit (MRP 2.0)
! = STLS check in for review and course corrections
!! = SPLWG oversight and review

Background

The San Francisco Bay Hg and PCBs TMDLs call for a reduction in loads by 50 and 90% by 2028 and 2030, respectively. In response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) called for a range of actions including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of loads of sediments and trace contaminants on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. These same needs were reflected in the small tributary loading strategy (STLS) (SFEI, 2009). On November 19, 2015 of the second MRP was issued and provided an updated set of management questions (provided below) (SFRWQCB, 2015).

During water year (WY) 2015, the RMP funded the new phase of a watershed characterization reconnaissance study aimed at locating more high leverage watersheds and sub-watersheds and developing a remote sampler method designed to decrease costs and increase ease of data collection in locations where sampling may be logistically challenged. The results from 20 locations collected using manual methods and for three locations using the remote sampler methods were recently reported (McKee et al., 2016 in SPLWG review). This report also collated previous data collected at 25 other sites in the Bay Area and provided a ranking of 45 sites. During the wet season of WY 2016, the same study design was continued with the successful collection of a further 17 locations using manual methods and for a further five locations using the remote sampler methods for a total of 66 sites now characterized[1].

[1] Data were also collected by the Santa Clara and San Mateo Stormwater programs using the watershed characterization reconnaissance study design. This data should be made available in later fall for comparison to the RMP data during the reporting phase of the project.

Through these efforts, an additional half dozen locations have been located that are showing highly elevated concentrations. Initial results also indicate that there is a reasonable comparison for PCBs between the particle concentrations observed from the remote samplers and particle ratios observed in the manual samples; data appear to indicated remote methods may be less well suited for Hg. Grainsize work completed in WY 2016 is expected to help resolved the differences observed and more nuanced interpretations. Also during 2016, funding was provided for further development and calibration of the RWSM and for development of the watershed loadings *Trends Strategy*. Data from the watershed characterization reconnaissance study is being used to help calibrate and verify the model outputs and will help to form the baseline of data to support future trends evaluations.

Study Objectives and Applicable RMP Management Questions

The main study objectives are two-fold:

1. Find watershed or sub-watershed locations with high concentrations of PCBs, Hg and other priority pollutants and rank these locations relative to each other and sources.
2. Develop and test two remote sampler designs (the Hamlin and the Walling tube) for characterization of particle concentrations and comparison to manual methods.

These address management question (MQ) 1 and 2 primarily but also support MQ 4 by providing calibration data for the Regional Watershed Spreadsheet Model and MQ 5 as possible baseline data for regional stormwater trends assessment, and less directly MQ 3 by providing a regional map of concentrations and loads for baseline comparison to the effects of BMP application.

MRP 2.0 Q1:	Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2:	Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3:	Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4:	Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5:	Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

A wet weather field monitoring program proposed to continue in the WY 2017 winter sampling season that will largely mimic, with the exception of some minor improvements, the program implemented during WY 2011 (McKee et al., 2012), WY 2015 (McKee et al., 2016, in SPLWG review), and WY 2016 (preliminary results presented at the May 2016 SPLWG meeting).

- Monitoring Design:
  - Collection of 1 composite stormwater sample per site collected during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using one of three manual sampling techniques employing clean hands protocols (D95, b-reel, and boom-truck water quality sampler at sites with larger watershed areas, DH81 water quality sampler, or an ISCO pumping sampler)
  - Collection of 1 settled suspended sediment stormwater sample per site collected during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using one or both of two remote sampling techniques (Hamlin or Walling tube)
- Site Selection: A balance between two overarching rationale:
  - Nested sampling design to track sources upstream in known polluted areas to help better define source areas and management options.
  - Finding new polluted watersheds or sub-watershed areas (watershed locations near the Bay margin or further downstream than the source tracking approach).

  - Other selection rationale:
    - Larger watersheds with an existing USGS gauge
    - Re-sampling potential false negatives especially where there is putative evidence
    - Contingency for resampling Guadalupe River for trends
    - Filling gaps along environmental gradients in relation to source areas (most specifically to support RWSM development [MQ4])
- Number of sites: Dependent on site logistics, proximal site associations, analytes, budget and other factors, but likely 10-12 sites.
- The 2016 analytes list be continued (PCBs, Hg, SSC, TOC, grainsize, salinity)

Reporting

The outcome of the study will be a technical report (draft in December 2017; final in March 2018). The draft report will include the 2017 data and perhaps some more interpretative reporting including statistical analysis of the land use and source areas context and comparison to selected literature. The main objectives of the report will be to 1) document the outcomes of the remote sampler sub-study and describe the circumstances for its possible inclusion into future sampling programs; and 2) report and rank concentrations and particle ratios observed at each location and compare these to existing data.

Linkages to other RMP Workgroups

Some of the sampling sites may be selected in the watersheds of the Priority Margin Units (PCB WG) and monitored for emerging contaminants with funding from the ECWG.

References

McKee, L.J., Gilbreath, A.N., Hunt, J.A., and Greenfield, B.K., 2012. Pollutants of concern (POC) loads monitoring data, Water Year (WY) 2011. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Small Tributaries Loading Strategy (STLS). Contribution No. 680. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/pollutants-concern-poc-loads-monitoring-data-water-year-wy-2011

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