RMP Sources Pathways and Loading Workgroup Meeting Package

RMP Sources, Pathways and Loadings Workgroup Meeting

May 23, 2022 10:00 AM – 3:00 PM
and
May 25, 2022 10:00 AM – 2:30 PM

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DAY 1 AGENDA - May 23rd

1.	**Introductions and Goals for This Meeting** The goals for this meeting: ● Provide the Water Board and Permittee perspectives on the SPLWG management questions, the Municipal Regional Permit (MRP 3.0) and related stormwater program activities (today) ● Provide updates on recent and ongoing SPLWG activities (today & tomorrow) ● Inform group of project proposals in other workgroups that relate to SPLWG (tomorrow) ● Discuss SPLWG proposals for the next fiscal year (tomorrow) ● Recommend which special study proposals should be funded in 2023 and provide advice to enhance those proposals (tomorrow) Meeting materials: 2021 SPLWG Meeting Summary pages 7-24	10:00 Melissa Foley

2.	**Information: Strategy and Management Questions Review and Upcoming Update** The SPLWG is currently undergoing a transition from a focus on monitoring and modeling legacy pollutants towards a greater focus on a more integrated monitoring and modeling approach for contaminants of emerging concern. In light of this transition and the release of the new Municipal Regional Permit, it is an important time to revisit the guiding strategy and management questions for the workgroup. This revision process will be funded in 2023 and the workgroup will hear the plan for this upcoming revision. Desired Outcome: Informed Workgroup	10:15 Alicia Gilbreath
3.	**Information: SF Bay Regional Water Quality Control Board Perspectives** Review of how the MRP 3.0 relates to the SPLWG and the management questions. Desired Outcome: Informed Workgroup	10:25 Richard Looker
4.	**Information: Permittee Perspectives** Review of the MRP 3.0 and how it relates to the Permittee stormwater program activities versus the SPLWG activities, and other stormwater program activity work Desired Outcome: Informed Workgroup	10:45 Chris Sommers
5.	**Scientific Updates on Current Projects: Introduction** The rest of today's workgroup meeting will be focused on providing updates on recent and ongoing SPLWG activities, and preparing the workgroup for discussion tomorrow about the proposals for 2023.	11:05 Alicia Gilbreath
6.	**Scientific Update: Integrated Monitoring and Modeling Strategy** Provide an update on the progress on this umbrella project that was funded last year to help us transition away from a PCB and Hg centric monitoring-based program for answering management questions to a more cost effective, integrated modeling-monitoring approach that is applicable to a wide range of pollutants. Here we will outline the progress to-date on a framework for integrated modeling and monitoring and get further directional input. We expect a full draft to be ready for SPL review this summer so input now will help to further shape direction. Desired Outcome: Informed workgroup. High level input on general direction.	11:20 Lester McKee
	Lunch	11:40
7.	**Scientific Update: Stormwater Monitoring Activities** RMP stormwater monitoring activities in Water Year 2022 included monitoring for legacy pollutants (PCBs and Hg) using both the reconnaissance method as well as at flow gauges to support modeling, monitoring for a suite of contaminants of emerging concern, monitoring for PCBs in watersheds that discharge to priority margin units, and monitoring for suspended sediment at four gauging stations to support sediment loads modeling for the region. WY 2022 has been a dominantly dry year, however, the RMP	12:20 Alicia Gilbreath

	team successfully sampled at several sites during four storm events. The workgroup will hear an update on this effort and plans for WY 2023. Desired Outcome: Informed Workgroup	
8.	**Scientific Update: Watershed Dynamic Model (WDM) Development to Support Watershed Loads and Integrated Watershed Bay Modeling Strategy and Pilot Study** The workgroup will hear updates of two modeling related projects, the progress of the multi-year modeling project, WDM and modeling visions from the integrated watershed Bay modeling strategy and in-Bay modeling strategy. The WDM update is mainly about the phase two sediment modeling results and the model assumptions and POC (PCBs and Hg as pilots) modeling methods. The update of the integrated watershed Bay modeling strategy and the in-Bay modeling strategy will discuss the priority SPLWG management questions that can be answered by watershed and in-Bay modeling projects. Desired Outcome: Informed Workgroup; feedback on modeling design and modeling strategy.	1:00 Tan Zi, David Peterson
9.	**Scientific Update: Stormwater CECs Monitoring Approach** The workgroup will hear an update on the RMP sponsored 2-year effort to develop a CECs monitoring strategy for stormwater. The strategy will integrate modeling to cost-effectively address near-term priority RMP management questions for CECs in stormwater, including presence and loads relative to other pathways. The project will develop (1) an approach for prioritizing CECs for stormwater monitoring, and (2) a process for integrating modeling when developing CEC-specific stormwater monitoring study designs. The proposed *CECs in Stormwater: PFAS* project would pilot this approach while in parallel building resources to support all future stormwater CECs monitoring. Desired Outcome: Informed Workgroup; Discussion: requesting feedback on monitoring approach design.	2:00 Kelly Moran, Alicia Gilbreath
	Adjourn	3:00

DAY 2 AGENDA - May 25th

10.	**Summary of Yesterday and Goals for Today** The goals for today's meeting: ● Brief recap of yesterday's discussions and outcomes ● Update on the tires strategy ● Brief update on projects or proposals from other workgroups that have connection to the SPLWG ● Presentation of proposals for fiscal year 2023. ● Discuss and recommend/prioritize which special study proposals should be funded in 2023 and provide advice to enhance those proposals	10:00 Melissa Foley
11.	**Scientific Update: Tires Strategy Update** In 2021, the RMP funded development of a cross-workgroup multi-year plan to address tire-related water pollution ("Tires Strategy"), focusing on contaminants. This 5-year plan builds from the Tires Conceptual Model project, which was funded in 2020 and is nearly complete. It identified key information gaps around the connections between tires and aquatic habitats. International scientific research into this high-interest, high-impact area is starting to clarify aquatic hazards posed by tire particles and some chemicals (e.g., 6PPD-quinone) and starting to identify additional associated chemicals of ecological interest. Monitoring data and information about emission, fate, transport, and mitigation options remain relatively limited. Within this rapidly changing context, a short-term RMP multi-year plan is in development. Once the science has solidified (anticipated by the end of the plan's 5-year horizon), tire-related work would fold into the emerging contaminants and microplastics strategies. The plan is intended to be based on stakeholder needs and the special capabilities of the RMP. Desired Outcome: Informed Workgroup. Brief Discussion: requesting feedback on approach	10:15 Kelly Moran
12.	**Other Workgroup Projects/Proposals with Connections to SPLWG** ● Stormwater CECs monitoring approach year 2 of 2, ECWG ● Tire and roadwater contaminants in wet season Bay water (Year 1 of 2, ECWG) ● Microplastics air monitorings (MPWG) ● Tributary Suspended and bedload flux monitoring in Napa and Sonoma Rivers (SedWG) Desired Outcome: Informed Workgroup	10:30 Kelly Moran, Lester McKee
13.	**Summary of Proposed SPLWG Studies for 2023**	10:40 Alicia Gilbreath, Tan Zi

	The SPLWG science leads will present the proposed special studies. Clarifying questions may be posed, however, the workgroup is encouraged to hold substantive comments for the next agenda item. 2023 RMP SPLWG Special Study Proposals include: ● Stormwater PCBs and Hg Monitoring to Support Modeling ● CECs in stormwater: PFAS ● Remote sampler development for tidal areas and pilot testing ● WDM to Support Watershed Loads and Trends for Hg and PCBs (year 2) ● Stormwater CECs modeling Meeting materials: 2023 Special Studies Proposals, pages 25 - 61.	
	LUNCH	12:00
14.	**Discussion of Recommended Studies for 2023 - General Q&A, Prioritization** The workgroup will discuss and ask questions about the proposals presented. The goal is to gather feedback on the merits of each proposal and how they can be improved. The workgroup will then consider the studies as a group, ask questions of the Principal Investigators, and begin the process of prioritization by stakeholders.	12:30 Melissa Foley
15.	**Closed Session - Decision: Recommendations for 2023 Special Studies Funding** RMP Special Studies are identified and funded through a three-step process. Workgroups recommend studies for funding to the Technical Review Committee (TRC). The TRC weighs input from all the workgroups and then recommends a slate of studies to the Steering Committee (SC). The SC makes the final funding decision. For this agenda item, the SPLWG is expected to decide (by consensus) on a prioritized list of studies to recommend to the TRC. To avoid an actual or perceived conflict of interest, the Principal Investigators for proposed special studies are expected to leave the meeting during this agenda item. Desired Outcome: Recommendations from the SPLWG to the TRC regarding which special studies should be funded in 2023 and their order of priority.	1:20 Chris Sommers
17.	**Report Out on Recommendations**	2:20 Chris Sommers
	Adjourn	2:30

REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY
sfei.org/rmp

RMP Sources Pathways and Loadings Workgroup Meeting

May 26-27, 2021 (teleconference)

Meeting Summary

Advisors	Affiliation
Tom Jobes	Independent
Jon Butcher	Tetra Tech

Attendees:

- Alicia Gilbreath (SFEI)
- Bonnie de Berry (EOA/SMCWPPP)
- Bryan Frueh (City of San Jose)
- Chris Sommers (SCVURPPP / EOA)
- Don Yee (SFEI)
- Jay Davis (SFEI)
- Jon Konnan (EOA/SMCWPPP)
- Kelly Moran (SFEI)
- Lester McKee (SFEI)
- Lisa Austin (Geosyntec Consultants)
- Lisa Sabin (SCVURPPP / EOA)
- Luisa Valiela (EPA)
- Melissa Foley (SFEI)
- Nina Buzby (SFEI)
- Paul Salop (AMS)
- Rebecca Sutton (SFEI)
- Richard Looker (SFBRWQCB)
- Setenay Frucht (SFBRWQCB)
- Tan Zi (SFEI)

The last page of this document has information about the RMP and the purpose of this document.

Day 1

1. Introduction

Melissa Foley began the meeting by reviewing remote meeting etiquette and noting that the workgroup advisors would get precedent during the discussion period. She also did a land acknowledgement referencing the indigenous communities on whose land the RMP operates. The workgroup advisors Dr. Jon Butcher and Tom Jobes introduced themselves, and Melissa noted that the third advisor, Dr. Barbara Mahler, was involved in a car accident and was unable to attend.

While going over the agenda for each day of the meeting, Melissa also provided background on the Bay RMP and WG structure, as well as how special studies factor into the greater program budget. Related to the available funding, Melissa explained that the 2022 budget is somewhat in flux due to the Status & Trends redesign efforts. She also noted the increasing amount of cross-workgroup collaboration that occurred in the proposal writing process.

2a. Information: Review of Management Questions

Richard Looker provided context from a regulatory perspective and reminded the group of the 2020 meeting's emphasis on the transition away from legacy contaminants and growing need to integrate with other workgroups. Based on these changing needs, Richard suggested that the update/revise the management questions in the near future.

While reviewing the existing SPLWG management questions (MQ), Richard provided his take on where the group is relative to each question's goals. For MQ1 (POC loads and concentrations), Richard explained that the group is likely in the finishing stages of PCB sampling and is beginning to ramp up on CEC monitoring efforts. For MQ2 (identify high leverage areas), Richard wondered if this question needs to be revamped for CECs. It is possible that this question is not important for CECs because they are more ubiquitous than legacy contaminants. For MQ3 (trends), the workgroup is making progress on the modeling front, which will help to assess trends over time. MQ4 (management opportunities in source areas) may need to be refined for CECs; the workgroup has some PCB info that is being used to address those issues. Finally, Richard highlighted MQ5 (impacts of management actions) as a tricky one for the RMP because it is a big question that requires a substantial investment that is bigger than the RMP. Richard suggested that the dynamic regional watershed model may help assess change over time for some management actions (land-use change), but the model may be too large scale to capture changes from smaller-scale actions such as PCB removals. Richard also suggested the group think about this question in the context of CECs and how management interventions could be represented in the model.

2b. Information: Overview of Related Stormwater Program Activities and Objectives

Chris Sommers continued the discussion by providing the stormwater perspective, and similar to Richard, acknowledging the program-wide transition to less focus on legacy pollutants and greater focus on CECs. Chris then reviewed various stormwater interests like trash monitoring, watershed-specific pollutants, green stormwater infrastructure (GSI), and others. Chris also acknowledged the efforts going on outside of the RMP related to stormwater interests and specific information needs related to CECs. Specifically, Chris showed the group a matrix of the proposed studies for 2022 and how they related to information needs.

Melissa Foley then referred to Richard's comment on updating the management questions, noting that there would not be time to do so during the meeting. However, she explained that the ECWG presented a proposal to update the CEC strategy, which could play into SPLWG question updates.

Scientific Updates on Current Projects

3a. Scientific Update: Stormwater Monitoring

Alicia Gilbreath reviewed the stormwater monitoring activities that involved a record number of efforts but also notable obstacles from drought conditions and pandemic challenges. She noted that given the poor rain conditions of the past season, SFEI hopes to conduct all the same stormwater monitoring activities with the addition of a study in Old Alameda Creek. Related to monitoring efforts, Alicia asked the group for their perspectives on how to continue monitoring and how to proceed with the growing CEC focus.

The following discussion focused primarily on the balance between reconnaissance and monitoring efforts to support the watershed model. Jon Butcher expressed interest in both reconnaissance sampling and monitoring to support modeling. He questioned whether there were other types of indicator monitoring in use that perhaps would be more efficient (e.g., biota indicators could be easier than sampling storms). It was noted that the passive sediment samplers have been in greater use since they were piloted by this program a few years ago, and the PMU studies have included both surface sediment sampling and small fish (with relative site fidelity). Don noted that biotic exposure is not typically used as a trigger for further investigations, and the CECs team is more interested in things that are slightly less persistent and don't dovetail with biotic accumulation.

Tom Jobes shifted the discussion to suggesting that interpretation of the data could potentially be improved by stratifying the data by storm size to better compare it. The ADA was then mentioned as a tool to do just that. It was acknowledged that overall the dataset is challenged by so few sites having multiple samples, especially samples from the same station representing different sized storm events, and Chris Sommers noted the inherent challenges in sampling, let alone sampling only for representative sized storm events.

The discussion ended with Richard Looker expressing Tom Mumley's sentiments that SPLWG work should be shifting away from reconnaissance monitoring and towards monitoring to support the modeling efforts. Tom Jobes agreed.

3b. Scientific Update: Regional LSPC Model Development to Support Watershed Loads

Tan Zi presented an update of the multi-year modeling implementation plan. Last year he completed the hydrologic modeling setup and is currently in the second phase developing the sediment model, which will be complete by the end of the year. The next step is to start POC simulations for Hg and PCBs, which is the proposal he will present on day two. He then dove further into describing the status of the sediment model as well as explaining some technical aspects of the model (e.g., # of watersheds, simulation time period, sediment classes) and general modeling approach split between land and in-stream processes. He noted that a revised land use dataset (ABAG) is expected to be completed by the end of the year; however, the impacts of using the older ABAG dataset should not make huge differences in the sediment modeling but newer data will be useful for POC simulations next year. He finished his update reviewing the proposed calibration criteria for the flow and sediment models. The literature has quite high standards and asked the group if there are any other criteria that have been used.

In the post-presentation discussion, Jon Butcher warned that the criteria Tan proposed from the literature was based on reproducing monthly loads in larger streams in the midwest, whereas it would be hard to reproduce those calibration criteria in smaller, flashier streams. He said it is less important what the calibration certainty is and more about how the model gets used - the uncertainty needs to be understood by the users. Tom Jobes agreed. Chris Sommers and Lisa Austin both shared local examples of useful modeling despite such high uncertainty occuring.

Jon Butcher finished the discussion noting how important it is to find additional lines of evidence, such as roughly predictive sediment exchange or potentially even geomorphology data from the channels. The model should describe channel vs. upland erosion processes. To ensure success of the model, Tan will need to make sure everyone is on the same page on how to deal with uncertainty after completing the calibration.

3c. Scientific Update: Advanced Data Analysis

Lester McKee and Lisa Sabin presented on the Advanced Data Analysis, which takes a detailed dive in interpreting the reconnaissance monitoring data in relation to runoff characteristics, runoff, land-use distributions, and congener profiles. Lester reviewed the basics of the analysis, using two primary methods:

1) Computing rank comparisons for each watershed’s storm yield, which provides three indicators (yield, particle concentration, and water concentration) to apply to a weight of evidence approach for management decisions/actions, and
2) Aroclor method with four steps to identify PCB aroclors present in each sample and in what amounts

He then presented a decision tree classification and suggested that about ¼ of the sites could be considered sampled under “benign” conditions, which leads to the question of whether larger storms might produce higher concentrations and thus these might be good sites for re-sampling since the data could be a false negative.

Lisa Sabin presented on how the municipalities are using such data from the ADA work; it is used to support identification of high/low priority catchments that are contributing elevated PCB stormwater loads, and the aroclor data provides information on potential sources within a catchment. She then provided a comparison example between the current prioritization method and utilizing ADA outputs. She also noted that an important remaining question is in how to identify low-priority catchments, and how low of an indicator measurement is low enough to knock it out of consideration for further investigation.

There was no time for additional discussion.

3d. Scientific Update: Integrated Monitoring and Modeling Strategy

Lester began this presentation explaining the project motivations and expectations and noting the goal of the item was to get input on the roadmap development related to the project. Kelly Moran then went on to describe how we want to integrate the watershed modeling and monitoring work to maximize effectiveness, and that this kind of strategy was particularly important for pollutants such as CECs because of the high analytical costs. Tan proceeded to present on the suggested workflow of the project, which is to look at management questions to identify data gaps and whether monitoring or models can answer/fill those gaps and how monitoring/simple modeling efforts could then inform more dynamic models. Lester then presented the questions up for discussion:

- What are the group's thoughts on how watershed modeling can help address the ECWG and SPLWG management questions?
- What is the correct road map/plan for sediment/PCB/Hg? and
- What are the most important near-term questions for modeling?

Lester also explained the timeline for reporting on these efforts (draft sep 2021).

Jon Butcher kicked off the discussion suggesting that the RMP should stay updated on what is happening in the Puget Sound where they are asking a lot of the same questions.

Richard recalled that one of the management questions - looking at big versus small loads for CECs - may need reframing, and that it may not be ambitious enough. Kelly clarified that the big vs. small question is more about whether or not the contaminant is worth considering in the stormwater context, relative to other sources.

Chris Sommers pointed out that the geographical scale should be considered, in part because the elements of the landscape/landscape features can change and whether assumptions are too broad.

Lester reminded the group of the iterative conceptual model development process; the conceptual model was refined for legacy contaminants as management questions got more detailed, and this will likely be the same case with CECs.

4. Proposals: Introduction

Melissa introduced the proposal presentation process, laying out that on Day 2, the group was going to see five proposals specifically for SPLWG, two of which were originally planned as SEP proposals, but which were upgraded due to additional carryover funds from last year's stormwater efforts being available. An additional seven proposals would be presented from the ECWG and MPWG that have a nexus with stormwater work, as well as potential for SPLWG oversight on the projects. It is not the role of SPLWG to rank-prioritize these other proposals, rather the RMP is asking for the group to identify any potential red flags from a technical perspective. Finally, not being presented, are other workgroup modeling studies from PCB and SedWGs that are also interconnected with SPLWG efforts. This is the most integrated group of studies ever!

5. Other Workgroup Proposals with Connections to SPLWG

CECs in stormwater: A multi-year study that was supposed to end in WY2021, but lack of rain necessitated continuation. This is a reconnaissance effort screening for contaminants from broad chemical classes.

Stormwater CECs monitoring strategy: This strategy is intended to develop a long-term approach, with the idea that it is efficient to spend money now in program planning to save money down the line. Another goal is to prioritize contaminants for monitoring and develop a sampling design approach that can answer management questions. The proposal for this study is requesting early release of funds to be able to have more to show at the 2022 ECWG meeting.

Ethoxylated Surfactants Study: Intended to fill in data gaps by investigating a longer list of chemicals and potential sources in wastewater.

Non-Target Analysis study in stormwater: intended to identify new contaminants for follow up monitoring. This has been done once in-Bay water during a wet season; the workgroup suggested focusing this effort on stormwater.

Tire strategy: Particles and their contaminants wear/wash off into storm drains and surface water. This proposal is to develop a short-term RMP strategy related to tires that is a cross-workgroup effort to identify data gaps.

Tire Particle Contaminant Fate/Transport: This study is not being funded by MPWG, but Kelly still shared this because it highlights a key data/information gap related to tire particles. Leaching potential is directly related to particle surface area, and we are currently unsure what tire particle sizes have the largest surface area (whether it’s the smallest ones that are transported in the air, or the larger, heavier ones that are falling on the road).

QUESTIONS/COMMENTS:
Bonnie de Berry commented that green stormwater infrastructure isn’t intentionally designed for tire particles but is likely capturing tire particles anyway. Kelly responded that bioretention can likely catch particles, but it is unknown what will happen to the contaminants/chemicals associated with those tire particles.

Chris voiced that these are all good studies, and it's going to be a challenge in funding everything.

6. Recap of Day 1 and Expectations for Day 2

The floor was opened for any additional questions/comments that remain related to project updates from earlier in the meeting.

Chris Sommers said he was not attending meeting day 2, and encouraged thorough consideration on the transition to greater CECs focus, keeping a critical eye on "where we are going" and to keep in mind previous experiences with Hg and PCBs. He felt all the proposals are worth doing, but it's more about how we want to address future priorities.

Related to the modeling presentation, Richard thought the delay of ABAG data will have the greatest impact on POC simulations, and wondered if it undercuts the possibility to calibrate the model? Tan said he didn't think there would be much effect on the sediment calibration, but he could do some recalibrating if there are large differences. With regards to the modeling proposal timeline, because of this delay, it is somewhat ideal to spread the modeling effort over two years, as Tan would much prefer to use the new ABAG dataset.

Melissa ended the day reminding folks to review the proposals in preparation for tomorrow's discussion.

Day 2

1. Introduction

Melissa provided a quick recap of the previous day (project updates and going over cross-workgroup proposals) and then gave an overview of the second day goals, which are to discuss proposals and then rank them. Prioritization would help the TRC to narrow down a number of studies to fit the actual funds available. One thing for the group to keep in mind is the option to scale/reduce study budget or phase over multiple years

2. Proposals

a. Proposal: Stormwater Monitoring for Continued Reconnaissance and to Support Modeling

Alica presented this proposal and noted the requested budget for the study is only $43K because of $100K carryover from WY 2021 due to a rainy season with few sampleable storms. The objectives of this study, which compete with each other to some extent, are to characterize concentrations, resample sites with insufficient data based on the results of the ADA work, and to provide more verification/calibration data for the Regional Model. She then showed a matrix outlining the objective, sampling method that would be used to meet that objective, and what the measurement outputs would support. She also outlined the approximate number of sites for each sampling method "option." She also noted that the reconnaissance sampling work does allow for CECs sampling piggy back.

Jon Konnan put in a plug for the need for continuing to dedicate adequate resources towards reconnaissance monitoring based on the general lack of samples used in ADA and model efforts. He noted that only one composite sample has been collected from most stations and suggested that in an ideal world we would have something like 3-5 samples per station, but acknowledged that unlikely to ever be achieved given the general lack of resources and storms to sample. He noted more PCBs data from both previously sampled and unsampled old industrial catchments would be valuable. Consistent with Water Board staff expectations, some countywide stormwater programs are trying to wrap up source property identification, and the PCB data would be particularly helpful towards that effort and to prioritize which catchments to focus our efforts given the limited resources available.

Richard responded that there is no guarantee that this reconnaissance monitoring is the best way to identify source properties. Richard also noted that the stormwater programs are ultimately responsible for collecting data to identify the catchments, so there is another source of funding (the municipalities) to do the re-sampling while there is not another source of funding (other than RMP) for the modeling needs and allowing CEC piggy backing. Richard pointed out that when determining the optimum design of monitoring strategy, we need to focus first and foremost on how best to address RMP management information needs. The RMP has spent a lot of resources in the past and still will spend some to help with identifying source areas, but this is just one information need among many, and the other RMP information needs need to take precedence now in designing the future monitoring strategy.

Richard liked the two options on the table that both included a combination of discrete and composite sampling. Alicia noted that we cannot piggy-back CECs sites on remote sampling, so we would have to do manual sampling wherever we wanted to piggy-back. It was asked if we could do discrete sampling for CECs and Alicia said the program is not yet ready to do that, although Lester noted we could take a composite sample for CECs at a site where we take discrete samples for PCBs. The challenge is that most sites of interest for discrete sampling have mixed-use watersheds that don't meet CEC site requirements - but there are a few sites that may meet both PCB and CEC needs.

Lisa Austin asked about North Bay sampling and also suggested that if we go with an option with fewer sampling locations, then Marin and Contra Costa counties would be the first priority areas. Alicia noted that it is tricky to distribute samples equitably.

While it was mentioned that we could determine the exact allocation of site numbers between different objectives, Melissa encouraged the group to come up with some guidance for the TRC on which options were highest priority.

b. Proposal: Regional Model Development to Support Watershed Loads and Trends

Tan presented a proposal on the next phase of the Regional Model effort, which is to model PCBs and Hg as a proof of concept for POC modeling and in anticipation of modeling less well-monitored pollutants such as CECs. The approach to developing the model will include two steps. The first is to parameterize the HRUs and secondly to conduct POC loading calibration and validation. The project deliverables would involve development of a presentation and report, and making the results/data publicly available. He presented two budgeting options including either a one year effort or a two year effort. The rationale for extending over two years is that we would be able to wait for the new ABAG land use layer to be completed, and we would have more POC data as well as the CECs conceptual model development to help inform future CECs modeling. The advantage of the one year effort is that we would have a quicker turnaround and opportunity to move our efforts along faster.

Richard Looker kicked off the discussion asking if Tan could complete a larger scope in the second year than what is currently being proposed if we went with the two year option. For example, could we also move into modeling select CECs? Tan responded that there are still a lot of unknowns with CECs, and we want to start with conceptual/simple models first, therefore we may not want to jump into modeling CECs with the Regional Dynamic Model. Discussion continued around making sure that the model is set up such that it can be used in the future for CECs, but noting that we will have even less data than what we are working with now for our more well-monitored POCs.

Conversation then shifted to discussing green stormwater infrastructure (GSI) and needing to be able to incorporate that data into the model to help explain changes in POC concentrations downstream and help inform calibration of the model.

Lisa Sabin indicated that information exists in the South Bay, but it is not necessarily all in one combined dataset. We will need to be a bit more specific on what exactly is needed and the level of detail required.

For example, Kelly noted that the mapping of control measures needs to include the type, since some types may be good for CECs control and others not.

Lisa Sabin responded that the control measures are focused on PCBs/Hg, so we would really need to specify what “control measures” other than GSI we would be interested in.

Lisa Austin also added that Contra Costa has a GIS database for redevelopment areas, noting that there are more trash controls than GSI.

Jon Butcher relayed that the practical implications of adding GSI to the model is challenging and would require delineating separate HRUs.

c. Proposal: CECs Remote Sampler Development and Pilot Testing

Alicia proposed a new project that entails developing a remote sampler that would work for CECs (because existing remote samplers are suspended sediment traps whereas CECs are more likely to be dissolved). The study would identify potential samplers, weigh up the pros and cons, choose and develop one and then pilot its use by collecting samples using the remote sampler side-by-side with manual collection and comparing the results. A likely candidate auto-sampler would be the ISCO, which collects whole-water samples but others would be considered before making a final decision. Development could involve modifying such a sampler and then blank testing the modified set up. The budget for the project would be dependent on the number of sites piloted. The project is time sensitive because WY2022 is the final ECWG CECs in stormwater effort and there is cost savings doing the two projects at the same time; the labor and analytical costs of the manually collected samples would be covered by the ECWG efforts.

In discussion, Lisa Austin was supportive and suggested the higher budget to allow for more pilot testing. She then asked if the decision on this proposal had a necessary connection with the reconnaissance monitoring proposal options and Alicia responded that it did not; the two projects would not necessarily need to share sites because, regardless of CEC piggyback on POC efforts, the CEC project would at least be sampling at six sites where the remote samplers could be deployed.

Richard asked Alicia to relay to the group why this project is useful. Alicia responded that the primary constraints in collecting samples are the number of storms per year and the staffing capacity, so using remote samplers that do not require staff to be present during the storm can expand the potential total sites we can sample.

Jon Konnan asked where things are at with the PCB remote sampling and how might those efforts inform development of CEC remote samplers. Alicia surmised that as legacy pollutant monitoring winds down, so will remote sampling for PCBs. However, we developed the remote efforts later in the process of legacy pollutant sampling, and now we can benefit from the foresight and we can develop and implement remote samplers towards the front-end of the CECs effort.

Bonnie asked about and Alicia reiterated that when the CECs and POC sampling efforts overlap at a site, the two sites share the labor costs for the sampling. Lester informed the group that the ADA project identified 36 sites that are candidates for resampling for PCBs. We could consider those sites to see which would be good for CECs too.

Bonnie asked about the logistics of deployment and Alicia responded that we haven't fully thought logistics through. Deployment of the ISCO will likely be more expensive than for the suspended sediment remote samplers. For example, we'll need to have some sort of vandalism protection and there will be a greater challenge in securing the tubing. Lester also noted that with the suspended sediment remote samplers, we don't have to ask for a permit, whereas we may need one for ISCO channel deployments depending on the site-specific type of vandalism proofing needed.

d. Proposal: Tidal Area Sampling Remote Sampler Development and Pilot Testing

Alicia began by saying this proposal was originally a SEP idea but it has now been elevated to a RMP proposal because there were extra carryover funds that could support an additional project. This project has a similar premise to the CEC remote effort, but in this case to develop and deploy a remote sampler that would be appropriate for sampling in tidally influenced areas. We normally have to sample upstream of high tide to prevent sampling Bay water, but there are many old industrial source areas that are within 2 km of the Bay margins, so the areas we most want to explore are often below the high tide mark. Sampling in tidal areas is possible but storm flow needs to align with the lower tide window in order to go out and sample tidal sites.

The idea for this proposal is to use a boat to access tidal sites and anchor a passive suspended sediment sampler in the water column along with a salinity probe. The salinity probe measurements would help us to interpret the results. The budget for this project is scalable based on the number of sites sampled.

Lisa Austin kicked off the discussion noting that Alameda County could benefit from this kind of sampling to help confirm estimates of loads based on street sediment data. She also mentioned a property she's interested in that discharges directly to the Bay and asked if it would be feasible to put a remote sampler in front of an outfall to the Bay? Alicia responded that if we are allowed to access the site, we could probably deploy a sampler but logistics could be challenging. In such a scenario, Lester warned that, at the scale of a single property or several properties, direct discharge to the Bay of a relatively small outfall flow may not lower salinity enough to allow for data interpretation with just a salinity probe. Don concurred that the salinity probe would not be helpful, but instead we could do a paired sample slightly upstream. For example, if a signal is similar to the nearfield average, we can assume that it is likely just background. But if we're seeing a difference at a factor of 5-10, then there is a higher likelihood of an upstream source.

Richard asked if we might be worried about the "sloshing" effect" (the contamination that is measured at the sampling location is actually sediment that was downstream previously and moved upstream of the sampling location on flood tide. This would be a confounding factor for the results). Lester agreed that there is a chance for false positives, but we haven't been able to sample these areas so perhaps it's better than nothing? We can also use this “pilot” effort to explore what scales we can investigate.

Bonnie expressed her support because it is so challenging to sample these MS4s. She asked how the information would be captured in the modeling efforts? Tan said we would need to check watershed boundaries to see if the marginal areas are included, and if so, he could use the data to inform loading and as validation data. The model could also be potentially used to help select sites for deployment.

Jay noted that the congener profiles could also help distinguish between outfall/Bay or backwash PCBs.

Jon Butcher said that they are dealing with similar problems in Seattle. They have data from marginal areas (mostly Boeing land) and have noted a lot of different PCB levels. It’s hard stuff to put into a model, and it would be worth asking the people in Seattle who are working on this.

Participants noted that this project has a low budget proposal, yet we may need to do a lot of reconnaissance work that we should factor in. Alicia acknowledged this was really just an effort for a few sites, and Don concurred that this is more about proof of concept.

e. Proposal: Desktop analysis comparing hydrology results between the monitoring data, RWSM outputs, and SFB regional watershed model

Tan presented a proposal to compare the hydrology outputs of the RWSM (regional watershed spreadsheet model) and Regional Watershed Dynamic models. Each of these models was designed for different purposes, but there could be benefits to comparing them in order to provide insights on uncertainties in each model. This comparison exercise could also help us to identify potential data gaps. In this project, we would do comparisons between a few major tributaries to determine tributaries with higher confidence or uncertainty. This could end up giving us ideas on how to improve both models based on the reasons of poorer performance of each. It would also be good in the context of CEC modeling; if we use the RWSM for modeling CECs, we could rely on the tributaries that we have determined have “greater confidence” in the calibration process.

Melissa noted that it would be good to hear about the group’s prioritization of this study, and if it is not prioritized for funding this year, can we list it as an SEP? We could also flag this as a backup desktop study if the region experiences another drought year and stormwater sampling does not use the full budget.

Lisa Austin began the discussion asking why do we care about the RWSM? Although it was an initial step, the stormwater programs are not likely to use it. She asked for more detail on how it will help to further develop the regional model. Additionally, we already know to some extent the shortcomings of the RWSM. Tan responded that the CEC modeling won't start immediately with the dynamic model. It is not yet decided what model to use for CEC modeling initially, but it could be the RWSM. Also, the comparison can highlight differences between the models. It's possible that the RWSM performs better in some watersheds on an annual average scale than the regional watershed dynamic model.

Tom Jobes expressed a similar reaction to Lisa. Would it be useful towards the calibration? Improving both models based on each other doesn't make sense. Lester reminded the group that originally we were unsure whether we could use a dynamic model for PCBs. One value of the development of the RWSM was learning how to aggregate the land use classes, and that last year Jon Butcher was in support of keeping the spreadsheet model. In large part this is because the RWSM is $10K-$20K effort per analyte, whereas the regional watershed dynamic model implementation for a new contaminant is closer to $60K. Lester also mentioned that the RWSM can be used to generate potency factors that would be used as a starting point in the new regional watershed dynamic model.

Kelly questioned that if we don't want to continue using RWSM then what approach do we want to use for initial load estimates for CECs (ECWG wants to try to understand relative loads)? Tom Jobes said that highlighting the uncertainty in the regional watershed dynamic model for CECs may be pessimistic since there is also a lot of uncertainty in using the RWSM. While screening level assessment using a model like the RWSM prior to using a dynamic model makes sense, he's not sure if the RWSM is the appropriate screening tool. Jon Butcher stated that the primary purpose of the RWSM going forward should be to aid the further development of the regional watershed dynamic model.

Bonnie suggested we compare the regional watershed dynamic model to the output from RAAs that the county-wide stormwater programs have developed and Tan felt it would be more useful to compare PCBs/Hg rather than flow in this scenario. Then Bonnie suggested this effort just be rolled into the modeling proposal if being used for calibration of the Regional Model. Tan responded that he sees the project as a way to improve both models, so it's not just for the regional watershed model. Lisa Austin felt the focus should be on the regional watershed dynamic model and less about improving the RWSM and we should integrate this comparison as part of the budget for the regional model proposal. If we want to spend time, money, and effort improving the RWSM, then we should come back to SPLWG unless ECWG is paying for it.

Lisa asked whether the ECWG considered this proposal. Melissa reminded the group that at the level of the TRC, the funding really comes from a single budget and it is the work of the TRC to take considerations of all the WGs together. There is some play in how many of the lower priority studies (3-5) get funded. Melissa also noted that unfunded projects can go on the SEP list and are eligible for those penalty funds.

Kelly expressed that we are not looking to compare watershed to watershed loads of CECs, rather we are wanting to compare rough regional scale estimates of total annual stormwater and total annual wastewater loads.

f. Proposal: SEP project concept level proposals in a programmatic context

Alicia shared a bit about the process of SEP projects and that it is not guaranteed funding. She then showed the recent SEP projects that have been completed in the last five years and noted how it can be a significant funding source (e.g., $700K over the last five years).

Alicia relayed that one of the newly funded SEPs is for updating the RWSM by improving its calibration using an improved ABAG land-use layer and an updated precipitation data layer (1990-2020 normalized time period), and we should discuss in the context of the prior proposal whether we want to do the RWSM-Regional Watershed Dynamic Model comparison before making any changes or vice versa.

LIsa Austin asked about the first project on the current SEP list that is about testing super composite samplers. Alicia explained that instead of collecting discrete samples a few times during a few storms like has been our study design in the past, this project proposal was to collect using automated samplers a large number of small subsamples throughout the season. Such a design could ensure we don't miss any storms that may export large episodic loads, and it could also save on analytical costs. Lisa asked if this was still useful in the context of PCBs, and also whether this might have application for CECs? Alicia said they hadn't considered doing this project for CECs since the idea initially was developed in 2017 when PCBs were a greater focus. Additionally, while PCBs have a year-long hold time, CECs typically have a shorter hold time so the design is not totally appropriate. Bonnie said some stakeholders still have an interest in learning about PCBs, and so she is in support of leaving it on the SEP list.

Lisa Sabin asked if we have looked into using passive samplers for CECs. Kelly responded that the idea has come up periodically, but nothing in the literature reports any passives that are ready to go for CECs.

Discussion then shifted to the SEP listing process. Melissa said it is possible to make changes to the SEP project proposals without going through the WG or TRC, but anything substantive should go through the WG for approval and then need to be ultimately approved by the TRC. If there are any new ideas for SEPs, the TRC meets each quarter and can review them. SPLWG can propose new SEPs at that time, but we would need to have the SPLWG sign off before bringing them to the TRC.

Lisa Austin brought up the question of whether we are allowed to put GSI effectiveness testing on the SEP list, and whether we could measure the effectiveness in addressing CECs. Melissa said no since GSI was outside of the RMP purview and would thus be a low priority of the program. Kelly said that, given the strong push to think about upstream impacts rather than treatments, the focus for CEC control would likely be more on source control than on the traditional TMDL/monitoring approach and unlikely to focus on treatment controls. Lester also noted for the group that some data will be collected on CEC performance in GSI from an externally funded effort (WQIF project) with San Francisco.

3. Prioritization Discussions

a. Discussion (Open): Recommended studies for 2022

Nobody had any final technical questions about the proposals before the SFEI staff left the main meeting room.

b. Decision (Closed): Recommendations for 2022 special studies funding and SEP list

The following table shows the proposed projects and budgets that were discussed during the closed session.

Study Name	Asking Budget	Modified Budget	Priority	Comments on prioritization
Small Tributaries Loading POC Watershed Reconnaissance Monitoring	$43,000 ($100K Carryover)	$43,000	1	$100k carryover from previous years
Regional Model Development to Support Watershed Loads and Trends	$90,000 - $150,000	$90,000	2	Split into two years to take advantage of the ABAG land use update; total budget $150k (relying on guaranteed funding of $60k in year 2)
CEC Remote Sampler Development and Pilot	$30,000 - $36,000	$36,000	3	More timely than tidal remote samplers
RWSM and Regional Watershed Model comparison	$25,000	$25,000	6	In the initial discussion group suggested rolling into a bigger model proposal; somewhat duplicative and lower priority; add input from RAA models? Comparison is only for flow, which added to the lower priority
Tidal Area Remote Sampler Pilot	$25,000 - $50,000	$50,000	5	Could start the project with $35k in order to keep the study
CEC stormwater load model exploration		$25,000	4	Review and identify loads modeling needs for CECs (continuation of integrate modeling and monitoring strategy project for modeling)

In addition to prioritizing the presented special studies proposals, the group also discussed priorities related to aspects of the stormwater reconnaissance monitoring. With recent dry years leading to very little sampling opportunities, the group made a specific suggestion on how to proceed if drought conditions continue. Their recommendations and comments are outlined in the table below:

Reconnaissance Sampling Options	Priority	Comments
all discrete (8) (no CEC piggybacking)		
remote (8)+ composite (8) (limited model application)		all composite sites will be CEC sampling criteria
composite (5)+ discrete (5) (CEC and model)	1	all composite sites will be CEC sampling criteria (ideal prioritization; storms will dictate exact locations to some degree)
remote (2) + composite (4) + discrete (4)	2 (backup for dry year)	all composite sites will be CEC sampling criteria; move to this option if we have limited storms in WY2022; possible addition of North Bay sample if rainfall locations drive changes

c. Report out on Recommendations

Bonnie began by thanking the proposal authors for their efforts. She then reported that there was not too much scaling back done to the budgets and went through the prioritization reasoning, e.g. the RWSM comparison is low priority because the hydrology of the RWSM is being updated. She also clarified that if that comparison work between the models was done, then the report should just cover the flow output.

There was a new study suggestion proposed by Richard and prioritized by the group. The effort was envisioned as a stepwise approach to developing needs for CECs modeling. The project should explore off-the-shelf methods to get screening-level loading estimates for CECs, using data that are going to be available soon. He noted that it would likely require some effort from ECWG folks, but it should be spearheaded by SPLWG interests.

Lester asked why we would not try out the RWSM for estimating CEC loads first? Richard said the RWSM could be one of the method options, but asked if the overhead needed for RWSM is cost-effective? Is it even too complicated for the needs? Don Yee said he thought that the RWSM works as a tool for worst/best case scenarios and to assess order of magnitude loads. Lester reminded the group that the RWSM can be used in a variety of ways. For example, if the CEC data are not sufficient yet for calibrating a pollutant RWSM, the hydrology can be output in relation to any CEC conceptual model as long as there are spatial layers based on those conceptual models to overlay on the hydrology layer. Doing this would allow the flow from the calibrated hydrology component of the RWSM to be output in a manner most appropriate for combining with the CEC concentration data to generate loads. Richard warmed to the idea of exploring different ways of using the RWSM. Kelly relayed that Richard suggested some literature review which could evolve into a more fleshed out project proposal for the coming year of what needs to be done on the RWSM or regional dynamic model. Richard asked if there were any lessons learned from microplastics RWSM modeling that we'd want to avoid with CECs. Jay added that the document from the project could detail how to use the RWSM most effectively, and in doing so could talk about the shortcomings of using it for microplastics. Lester warned (remarking on the PCB experience from 2006) that although we can get RWSM results for less money, we should really include funding for proper documentation that includes information on any caveats associated with the produced results so that, in say 5 years time, we can remember exactly how it was done.

Alicia and Melissa closed the meeting by expressing gratitude to the participants, advisors, and proposal writers.

Adjourn.

About the RMP

<u>RMP ORIGIN AND PURPOSE</u>

In 1992 the San Francisco Bay Regional Water Board passed Resolution No. 92-043 directing the Executive Officer to send a letter to regulated dischargers requiring them to implement a regional multi-media pollutant monitoring program for water quality (RMP) in San Francisco Bay. The Water Board's regulatory authority to require such a program comes from California Water Code Sections 13267, 13383, 13268 and 13385. The Water Board offered to suspend some effluent and local receiving water monitoring requirements for individual discharges to provide cost savings to implement baseline portions of the RMP, although they recognized that additional resources would be necessary. The Resolution also included a provision that the requirement for a RMP be included in discharger permits. The RMP began in 1993, and over ensuing years has been a successful and effective partnership of regulatory agencies and the regulated community.

The goal of the RMP is to collect data and communicate information about water quality in San Francisco Bay in support of management decisions.

This goal is achieved through a cooperative effort of a wide range of regulators, dischargers, scientists, and environmental advocates. This collaboration has fostered the development of a multifaceted, sophisticated, and efficient program that has demonstrated the capacity for considerable adaptation in response to changing management priorities and advances in scientific understanding.

<u>RMP PLANNING</u>

This collaboration and adaptation is achieved through the participation of stakeholders and scientists in frequent committee and workgroup meetings (see Organizational Chart, next page).

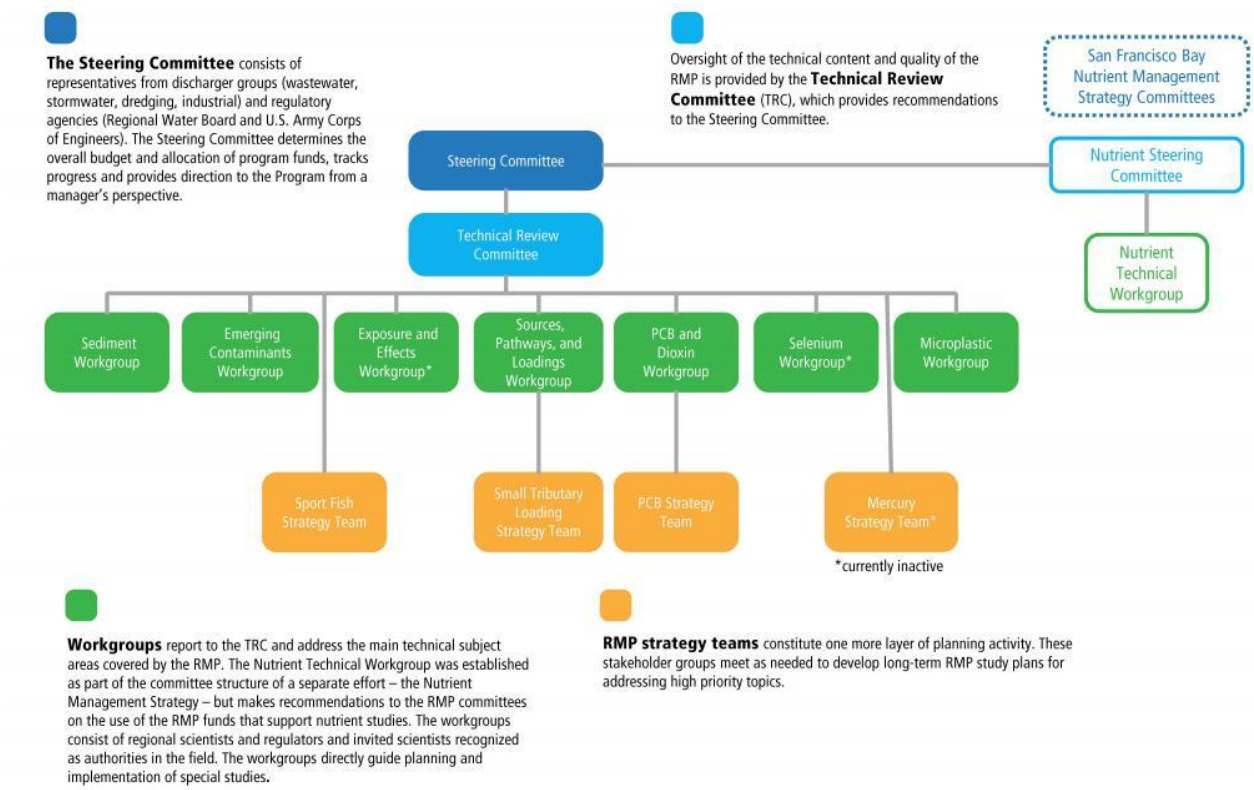
The annual planning cycle begins with a workshop in October in which the Steering Committee articulates general priorities among the information needs on water quality topics of concern. In the second quarter of the following year the workgroups and strategy teams forward recommendations for study plans to the Technical Review Committee (TRC). At their June meeting, the TRC combines all of this input into a study plan for the following year that is submitted to the Steering Committee. The Steering Committee then considers this recommendation and makes the final decision on the annual workplan.

In order to fulfill the overarching goal of the RMP, the Program has to be forward-thinking and anticipate what decisions are on the horizon, so that when their time comes, the scientific knowledge needed to inform the decisions is at hand. Consequently, each of the workgroups and teams develops five-year plans for studies to address the highest priority management questions for their subject area. Collectively, the efforts of all these groups represent a substantial body of deliberation and planning.

PURPOSE OF THIS DOCUMENT

The purpose of this document is to summarize the key discussion points and outcomes of a workgroup meeting.

Governance Structure for the
Regional Monitoring Program for Water Quality in San Francisco Bay



SPLWG Special Study Proposal: Small Tributaries Legacy Pollutant Discrete Monitoring to Support Modeling

Summary: The RMP has monitored stormwater throughout the region using two main techniques over the last 20 years. With the exception of 2011, from 2002 to 2014, intensive load monitoring (discrete sampling during at least four storms per year and at least two years but mostly three or more) was carried out at eight watersheds to compute loads in single watersheds and extrapolate these to estimate regional loads. In contrast, in 2011 and from 2015 to 2021, a reconnaissance monitoring style (single storm composite samples) was adopted to identify high-leverage watersheds of potential management interest. While reconnaissance monitoring cannot be used to support modeling, discrete samples at flow monitoring locations serve as important calibration data for the regional model. In this study, we propose a two-year effort for sampling at two sites during six storm events each, collecting four discrete samples over the hydrograph. This level of data is sufficient and optimal for supporting a cost-effective modeling-monitoring approach for loads and trends estimation to support the PCB TMDL reevaluation planned for 2028. After two years of sample collection, and in consultation with our modeling team, the SPLWG will decide whether to continue sampling these same two sites or to move on to new locations to support model calibration. This is primarily a field study and the level of effort will be tailored to the amount of budget available.

Estimated Cost: Total budget for the whole project: $150K **(**$10K funding requested for 2023 and utilizing $80k carryover from 2022, and $140K funding requested for 2024)
Oversight Group: STLS/SPLWG
Proposed by: A Gilbreath, D Yee, T Zi, and L McKee (SFEI)
Time Sensitive: Yes. Recalibration of the Watershed Dynamic Model requires multiple years of loads monitoring data. Therefore, we must begin sample collection now in order to have data available for recalibration in four to five years time.

Proposed Deliverables and Timeline

Deliverable	Due Date
Selected site list and preparation for sampling	09/2022
Wet season water samples collected and sent to the labs for analysis	2023 & 2024
Laboratory analysis, QA, & Data Management	09/2024
Interpretation & reporting for BAMSC	02/2025
Draft report	03/2025
Final report	06/2025

Background

San Francisco Bay TMDLs call for a 50% reduction in Hg loads by 2028 and a 90% reduction in PCB loads by 2030, respectively. To implement these TMDLs, the Municipal Regional Permit for Stormwater (MRP) (SFRWQCB, 2009; 2015; 2022) calls for the implementation of control measures to reduce PCB and Hg loads from urbanized tributaries. The MRP also identified information needs associated with improving understanding of sources, pathways, loads, trends, and management opportunities for contaminants. In response to the MRP requirements and information needs, the Small Tributary Loading Strategy (STLS) was developed, outlining a set of management questions (MQs; see Table 1) that have been used to guide the region's stormwater-related monitoring activities.

Over the past decade, the RMP Sources, Pathways, and Loadings Workgroup (SPLWG) and Bay Area Municipal Stormwater Collaborative (BAMSC) have focused on improving loads estimates mainly based on an intensive field-based monitoring approach, and identifying watersheds exhibiting high relative concentrations to help prioritize areas for greater management focus. However, as additional management efforts were implemented, the RMP asked if trends were starting to emerge. After completion of a pilot project to explore loading trends in a single watershed - the Guadalupe River watershed in San Jose where we have the best data set (Melwani et al., 2018) - it was recognized that repeating this exercise for a number of other watersheds would be cost prohibitive and that a regional watershed model would be needed to understand spatial and temporal trends in relation to management efforts at a regional scale. Now with a reevaluation of the PCBs TMDL planned for 2028, an updated robust estimate of PCB load and trends is needed to link management effort with load reduction progress and to link to the enhanced Bay modeling that is underway through the PCB workgroup.

Whereas in the past we have relied on collecting empirical data to explain the physics of local rainfall-runoff-based sediment transport and contaminant buildup and washoff processes in enough detail to estimate reliable loads to the Bay margins and Bay food web, going forward we plan to use an integrated modeling-monitoring approach that is more cost-effective. Starting in 2019, the regional Watershed Dynamic Model (WDM) has so far been developed for hydrology and sediment simulation with the present focus in 2022 on the baseline load modeling of PCBs and Hg with the trends component being proposed for 2023. Once calibrated, the WDM will dynamically simulate loading processes in the local watersheds surrounding the Bay, thus helping answer high priority SPLWG management questions about changing source characteristics and spatial and temporal trends related to management interventions, link these to changes in the Bay, and ultimately support the reevaluation of the PCBs TMDL.

However, the datasets to support a robust model calibration need some improvement. To better simulate the spatial heterogeneity and temporal dynamics of contaminant loadings to the Bay from local watersheds over time, the WDM needs contaminant load monitoring data (data with both concentration and flow rate) from representative watersheds to verify the load simulation. The load monitoring records need to represent both the spatial and temporal variations of the Bay Area (e.g., multiple events from different types of water years (WYs), different sites representing different land characteristics and management actions). Presently where there are still flow gauges operating, we have only one well sampled watershed (Guadalupe WY 2003-2014) and one moderately sampled watershed (Sunnyvale East Channel (2011-2014). More recent data for these two watersheds would be ideal for supporting the temporal aspect of model calibration. From a spatial standpoint, the existing data sets are also weak. No data have been collected in any of the larger north Bay watersheds and in total spatial data are only available for a very small portion of the Bay watersheds (4.5% for PCBs and 0.4% for Hg; Guadalupe River cannot be used for a regional Hg calibration due to the mining influences in that watershed). To support the reevaluation of the PCBs TMDL planned for 2028, these two data gaps need to be addressed.

Since the physics of contaminant processes are already represented in the model, when using an integrated modeling-monitoring approach, the monitoring data need not be as detailed as our past data collection styles for loads estimation where we monitored four storms per year over multiple years using a discrete sampling approach taking four samples per storm. Instead, the data need to be collected at a sufficient level to calibrate and validate the model physics. To broaden the dataset for regional model calibration and support the PCB TMDL reevaluation, we will engage the STLS stakeholders and SPLWG advisors to select two watersheds in the region that are gauged for flow, and sample these for PCBs, Hg, and SSC during six storms at each location over the course of two years.

Study Objectives and Applicable RMP Management Questions

This study will provide information essential to understanding concentrations of PCBs, Hg, and SSC by using discrete grab sampling at existing flow stations. The objectives of the project and how the information will be used are shown in Table 1 relative to the SPLWG high-level management questions.

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

Management Question	Study Objective	Example Information Application
Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay?	Use manual sampling to collect discrete grab samples at existing flow stations.	How do concentrations of POCs vary with flow during the course of a storm?
Q2: Which are the “high-leverage” small tributaries that contribute or potentially contribute most to Bay impairment by POCs?	N/A	N/A
Q3: How are loads or concentrations of POCs from small tributaries changing on a decadal scale?	Use this data to calibrate/verify the Regional Model.	What was the magnitude of loads at the regional scale during the period 1995-2010 versus 2011-2026 in relation to management intervention?
Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff?	Use this data to calibrate/verify the Regional Model.	How do watershed loads compare from one to another across the region?
Q5: What are the measured and projected impacts of management action(s) on loads or concentrations of POCs from small tributaries, and what management action(s) should be implemented in the region to have the greatest impact?	Use this data to calibrate/verify the Regional Model.	How are loads changing in relation to climate? What might be the future loads given reasonable changes in population, land and water management?

Approach

Sampling design

Since the objective of this monitoring is to support the improved calibration of the WDM, here we lay out a brief discussion of our rationale for the needed level of data. Over the past 20+ years we have carried out two levels of data collection. Our reconnaissance monitoring efforts were designed for discovering “high-leverage” watersheds that exhibited either high concentrations in water or on suspended sediment during storms. This information was used to help prioritize further source identification upstream. Just one composite sample from one storm was obtained per monitoring site. This type of composite monitoring data lacks the associated flow information and cannot be used to verify the accuracy of load simulation from the WDM, nor can these types of data provide the temporal variation information at the same monitoring site, which results in large uncertainties if model calibration is based on single events and modeled flow.

In contrast, the data collected at our fixed station loads monitoring sites where we often installed flow and turbidity sensors and then monitored at least four storms per year over multiple years using a discrete sampling approach taking two to seven samples and an average of four samples per storm, while very robust for model calibration for load simulation, the number of samples at each site is much greater than the model actually needs, and took extensive resources and time to collect. Data of this level of detail was needed to explain the physics of local rainfall-runoff based sediment transport and contaminant buildup and washoff processes in enough detail to estimate reliable loads for single watersheds, adjust these climatically to determine an annual average load, and then scale the loads using land use factors to estimate regional loads.

Since the WDM physics include detailed information about land uses and source areas, soil erosion, particulate and dissolved phase transport, surface and subsurface flow processes and channel storage and resuspension processes, a level of field data collection that falls in between the reconnaissance style methods and the intensive loads monitoring methods is needed. These data should be collected at the same sites during multiple storms over multiple years, and will therefore be robust enough to further support recalibration of the WDM within a few years.

Site selection

Consistent with earlier recommendations (McKee et al., 2015) to allocate some sampling resources to watersheds where there are existing flow monitoring gauges, a wet weather field monitoring program is proposed for the winter months of WY 2023, sampling at watersheds selected to support the development of the WDM. Potential sites for this sampling are listed below in Table 2, with the most ideal locations in **bold**. Note, all sites have flow gauges with the exception of Zone 4 Line A in Hayward, where a flow gauge would need to be reestablished, but we have included it in this table because it has such a large dataset covering many storms for that watershed (WY 2007-2010).

Table 2. Potential sampling locations for WY 2023. The watersheds we suggest for highest consideration are in **bold**

Watershed	Previous Sampling	Pros and Cons
Guadalupe River	Intensive loads style monitoring in WYs 2003-06, 2010, and 2012-14	Pro: Most robust water quality dataset in the Bay Area. Ideal for analyzing temporal trends. Large, urban watershed with diverse mix of land uses. Cons: Hg mine in upper watershed negates the data usage for Hg model calibration.
Novato Creek	Not previously sampled for water quality	Pro: Would add spatial heterogeneity to the model calibration data set. Con: Not previously sampled so no information about temporal differences.
Arroyo Corte Madera del Presidio	Not previously sampled for water quality	Pro: Would add spatial heterogeneity to the model calibration data set. Con: Not previously sampled so no information about temporal differences.
Walnut Creek	Sampled in WY 2011	Pro: Would add spatial heterogeneity to the model calibration data set. Collecting empirical data would be good due to the large sediment load from this watershed. Con: Previously sampled during only one storm and no flow measurement at the time.
San Lorenzo Creek	Sampled in WY 2011	Pro: Sampled previously in WY 2011 during two storm events (discrete sample n = X). Con: Only 13% impervious due to large, rural upper watershed.
Zone 4 Line A	Sampled WYs 2007-2010	Pro: Robust water quality dataset for WYs 2007-2010. 100% urban watershed with 30% industrial land use. Con: Would need to reestablish flow gauge.
East Sunnyvale Channel	Sampled in WYs 2011-2014	Pro: Pro: Robust water quality dataset for WYs 2011 (one storm), and WYs 2012-2014. Cons: flow record is questionable. If sampling Guadalupe River, this site would not add spatial heterogeneity.
Stevens Creek	Sampled in WY 2011	Con: Only one storm sampled in 2011.

Monitoring design

Two sampling locations with existing flow stations will be selected in collaboration with our modeling team and the STLS and our SPLWG advisors. We propose to collect four samples for

PCBs, Hg, and SSC over the course of each storm event, with the intention of collecting one or two samples on the rising limb, one at the peak, and one or two samples on the recession limb of the hydrograph for a total of four samples using manual sampling techniques. This is the same sampling approach that was designed using a statistical analysis of Guadalupe and Zone 4 Line A data available up to WY 2010, and that we used during our load monitoring program for WYs 2012-2014 for the Guadalupe River site (Gilbreath et al., 2015). In addition, the same approach will be used for storm selection. Samples will be collected during rainfall events that are forecast to exceed 0.5 inches of rainfall in a 6-hour period. A minimum rainfall of 0.5 inches represents the best compromise between active pollutant transport processes and the avoidance of false starts - when a field team is deployed but fails to sample due to the lack of rainfall. Discrete samples will be collected using either a D-95 suspended using a crane and winch assembly (larger channels) or a DH-81 or ISCO pumping sampler (smaller or wadable channels) following clean hands procedures using appropriately prepared and calibrated sampling equipment.

Stormwater monitoring for pollutants of concern occurs in parallel with multiple other RMP stormwater monitoring efforts including for the Emerging Contaminants Workgroup (ECWG), the PCBs Workgroup (PCBWG), and potentially future work overseen by the Sediment Workgroup (SedWG). Decisions about where to monitor during each storm will be supported by a decision tree that will be developed in consultation with those WG leads.

Laboratory analytes

Water samples will be analyzed for PCBs, Hg, and SSC. SGS AXYS Analytical will analyze for PCBs, Brooks Applied Laboratories will analyze for Hg, and SFEI will measure the SSC. We have long experience working with these laboratories and expect the data to be high quality.

Budget

The following budget represents estimated costs for this proposed special study for 2023 (Table 3) and 2024 (Table 4), assuming four discrete grab samples (per site) are collected during three storms at two sites each year. Note, the total budget for 2024 is higher than in 2023 because of the data management and reporting tasks to be done only in the second year for cost efficiency.

Table 3. Proposed budget (2023).

Expense	Estimated hours	Estimated Cost
Labor		
Project Staff	330	$44,000
Project Management	75	$7,700
Subcontracts		
SGS AXYS Analytical, Brooks Applied Laboratories, USGS		$32,300
Direct Costs		
Equipment		$1,000
Travel		$1,000
Shipping		$4,000
Grand Total	405	**$90,000**

Table 4. Proposed budget (2024).

Expense	Estimated hours	Estimated Cost
Labor		
Project Staff	330	$44,000
Project Management	75	$12,700
Data Management	160	$20,000
Reporting	165	$25,000
Subcontracts		
SGS AXYS Analytical, Brooks Applied Laboratories, USGS		$32,300
Direct Costs		
Equipment		$1,000
Travel		$1,000
Shipping		$4,000
Grand Total	730	**$140,000**

Budget Justification

- *Field Costs:* This special study proposal has a budget in 2023 of $90,000, which includes up to $44,000 devoted to stormwater sample collection (site selection and reconnaissance, permit applications, development of sample collection protocols, and field work for sampling six storm events).

- *Laboratory Costs:* Up to 30 independent samples will be analyzed each year, including field duplicates and field blanks. Analyses will be conducted for PCBs, mercury, and suspended sediment concentration.
- *Data Management Costs:* Data services will include quality assurance and upload to CEDEN.
- *Reporting Costs:* Preparation of a draft and final report on the results will be completed.

Reporting

The outcome of the study will be a concise technical report, written after the second year of sampling. The main objective of the technical report will be to detail the results of the discrete data collected that can be used to support modeling, and will also include the approximation of a time-weighted composite in order to rank the concentrations and particle ratios against other site composites sampled in previous years. The quality-assured data will also be delivered to the modeling team for inclusion in the Watershed Dynamic Model calibration and verification.

References

Gilbreath, A.N., Hunt, J.A., Wu, J., Kim, P.S., and McKee, L.J., 2015. Pollutants of concern (POC) loads monitoring progress report, water years (WYs) 2012, 2013, and 2014. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 741. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/sites/default/files/biblio_files/FINAL_WY2014_POC%20loads%20progress%20report.pdf

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 RMP, SPLWG, STLS. Contribution No. 680. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/documents/pollutants-concern-poc-loads-monitoring-data-water-year-wy-2011

McKee, L.J. Gilbreath, N., Hunt, J.A., Wu, J., and Yee, D., 2015. Sources, Pathways and Loadings: Multi-Year Synthesis with a Focus on PCBs and Hg. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). SFEI Contribution No. 773. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/sites/default/files/biblio_files/MYSR%20Final%20Report.pdf

Melwani, A.R., Yee, D., McKee, L., Gilbreath, A., Trowbridge, P., and Davis, J.A., 2018. Statistical Methods Development and Sampling Design Optimization to Support Trends Analysis for Loads of Polychlorinated Biphenyls from the Guadalupe River in San Jose, California, USA, Final Report.

https://www.sfei.org/documents/statistical-methods-development-and-sampling-design-optimization-support-trends-analysis
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. Contribution No. 585. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/sites/default/files/biblio_files/Small_Tributary_Loading_Strategy_FINAL.pdf
SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/index.shtml
SFRWQCB, 2015. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order No. R2-2015-0049, NPDES Permit No. CAS612008. November 19, 2015. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/R2-2015-0049.pdf
Wu, J., Trowbridge, P., Yee, D., McKee, L., and Gilbreath, A., 2018. RMP Small Tributaries Loading Strategy: Modeling and trends Strategy 2018. Contribution No. 886. San Francisco Estuary Institute, Richmond, California. https://www.sfei.org/documents/rmp-small-tributaries-loading-strategy-trends-strategy-2018
Wu, J., and McKee, L.J., 2019. Modeling Implementation Plan-Version 1.0. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Contribution No. 943 San Francisco Estuary Institute, Richmond, California. https://www.sfei.org/documents/regional-watershed-model-implementation-plan
Zi, T., McKee, L., Yee, D., and Foley, M., 2021. San Francisco Bay Regional Watershed Modeling Progress Report, Phase 1. Report prepared for the Sources Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality. SFEI Contribution #xxx. San Francisco Estuary Institute, Richmond, CA. www.xxx

Special Study Proposal: CECs in Stormwater: PFAS

Summary: This study will pilot portions of the Stormwater CECs monitoring strategy that is in development and will develop a study design appropriate for estimating the annual load of PFAS entering the Bay via the stormwater pathway. While this study will include some stormwater monitoring, its primary focus is to complete the groundwork necessary to develop a robust, practical, and cost-effective study design for stormwater PFAS monitoring that could be implemented starting in Water Year (WY) 2024. Proposed project elements include: (1) developing a preliminary conceptual model for PFAS in urban runoff; (2) analyzing prior PFAS monitoring data to inform monitoring design; (3) filling out the SFEI stormwater sampling site database to include sites and site characteristics needed for PFAS monitoring site selection; (4) developing a limited study design to pilot PFAS remote sampling methods; (5) developing and piloting testing remote samplers for PFAS sample collection, including stormwater and blank sample collection; (6) PFAS chemical analysis, data management, QA review, and data interpretation; and (7) preparation of a PFAS monitoring study design, which would be ready for implementation in WY 2024.

Estimated Cost: $180,000
Oversight Group: ECWG and SPLWG
Proposed by: Alicia Gilbreath, Kelly Moran, Rebecca Sutton
Time Sensitive: Yes, because it pairs with the second year of the Stormwater CECs Strategy project

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Data analysis to inform monitoring design and preliminary conceptual model development	Fall 2022-Summer 2023
Task 2. Sampling location data assembly & addition to database	Fall 2022-Summer 2023
Task 3. Remote sampler development and pilot testing including field collection of stormwater samples	Winter 2022-Spring 2023
Task 4. Laboratory analysis of pilot testing samples	Spring-Summer 2023
Task 5. Update presentations to ECWG and SPLWG	Spring 2023
Task 6. Data management and quality assurance	Summer 2023
Task 7. Data interpretation and development of study design	Spring-Fall 2023
Task 8. Draft Study Design Report	Fall 2023
Task 9. Final Study Design Report	December 2023

Background

The RMP funded the first year of a two-year study to develop a stormwater CECs monitoring approach ("Stormwater CECs Strategy") during CY 2022 and 2023 (the RMP will consider funding the second year of that project in parallel with this project proposal). Due to high CECs monitoring costs and technical challenges, a well-thought out, carefully focused approach is essential and the first step in establishing a long-term stormwater CECs monitoring program that addresses both ECWG and Sources, Pathways, and Loadings (SPL) management questions, such as estimating CECs loads discharged to the Bay via urban stormwater runoff. The approach will contain procedures and processes to form the basis of developing sampling plans for CECs monitoring projects.

A cornerstone of the new stormwater CECs monitoring approach is the integration of modeling and monitoring designs to maximize the value of each sampling event. A second key element of the stormwater CECs monitoring approach is the use of remote samplers to reduce sample collection costs and to increase the number of samples that can be collected during each storm event. This project will pilot implementation of the new stormwater CECs monitoring approach and build out resources to support its implementation (e.g., remote samplers and a monitoring site selection database). The new stormwater CECs monitoring approach is chemical-specific, recognizing that each individual CEC or class has different sources, fate, transport, and sampling challenges. No single monitoring study design can provide a timely, cost-effective data set to support stormwater load estimates for all CECs. However, the process developed in this pilot will be used to develop monitoring designs for other CECs. PFAS were selected for this pilot project based on their status as a Moderate Concern CEC in the RMP tiered, risk-based framework for prioritizing CECs, high priority at the state level, stakeholder interest, and data availability from past and parallel projects.

PFOS, PFOA, and other PFAS have been previously detected in San Francisco Bay biota, sediment, and water, including wastewater and stormwater pathways. Surface water monitoring conducted in 2009 found detectable levels of various PFAS, especially in areas impacted by wastewater and stormwater.

The RMP's PFAS Synthesis and Strategy (Sedlak et al. 2017, Sedlak et al. 2018) reviewed two studies of stormwater that have been conducted in the Bay Area: a seven site study conducted in water year 2010 (October 2009 through September 2010), and a 10 site study conducted in water year 2011. A relatively small number of PFAS were monitored; in addition, the watersheds monitored were not specifically selected to provide representative data for these contaminants in the Bay Area. The PFAS Synthesis and Strategy recommended stormwater monitoring as an RMP priority for future work. These studies, as well as the known toxicity and persistence of PFAS, led to classification of PFAS as Moderate Concern within the RMP tiered risk-based framework.

In Water Years 2019-2022, the RMP funded a multi-year effort to screen Bay Area stormwater for CECs, including PFAS. Thirty-one samples have been collected to date. Significant improvements in analytical methods now allow for a greater ability to characterize PFAS, including more short-chain PFAS. Data from the first year has been reported from the analytical lab to SFEI and could be used for study design development in this proposed project. The full dataset from this four-year study will be analyzed later this year.

Currently, as part of the Status and Trends (S&T) pilot wet season monitoring effort during the winter of 2021-2022, a study is in progress to assess PFAS in ambient Bay water samples. The wet season study design includes the collection of 10 samples (including two duplicates and field blanks) at six ambient sites in the Lower South Bay after one storm event. The sites were also characterized for PFAS in the summer of 2021, allowing a direct comparison of concentrations by season. Additionally, PFAS samples are being collected at the mouth of three creeks (one in each San Mateo, Santa Clara and Alameda Counties) directly after two storm events. These data will contribute to understanding the role of the stormwater pathway to the Bay.

Taken together, these past and parallel efforts form a strong context for a more intensive monitoring program for PFAS in stormwater. In addition to piloting the stormwater CECs monitoring approach, this study is designed to complete the groundwork necessary to develop a robust, practical, and cost-effective study design for stormwater PFAS monitoring to answer the near-term priority management question of whether the local watershed PFAS runoff load to San Francisco Bay is big or small as compared to loads from other pathways (e.g., municipal wastewater), as well as to develop a robust initial dataset for more intensive dynamic modeling and total mass load estimation to the Bay.

If this project is implemented, we intend to explore the potential for collaboration with three ongoing efforts. First, the State Water Board Surface Water Ambient Monitoring Program Stream Pollution Trends Program (SWAMP-SPoT) is piloting measurements of PFAS in bed sediment at the base of urban watersheds, including up to four sites in the San Francisco Bay area. These data could be leveraged to enhance our understanding of PFAS transport in urban watersheds, particularly for the long-chain PFAS. Second, the University of Toronto (Miriam Diamond), the Green Science Policy Institute (GSPI), and additional collaborators have a project underway examining PFAS in outdoor building materials, a likely (and perhaps major) source of PFAS in urban runoff. This project will inform the conceptual model and could influence the selection of sampling locations. Third, the USGS has started development of a second-generation low cost remote stormwater sampler based on a proven US EPA design (Kahl et al., 2014). We are currently exploring partnering with USGS to pilot this sampler in WY 2023.

Study Objectives and Applicable RMP Management Questions

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

Management Question	Study Objective	Example Information Application
1) Which CECs have the potential to adversely impact beneficial uses in San Francisco Bay?	N/A	
2) What are the sources, pathways and loadings leading to the presence of individual CECs or groups of CECs in the Bay?	Pilot portions of the Stormwater CECs Monitoring Strategy that is in development. Develop data to support estimating the annual load of PFAS entering the Bay via the stormwater pathway.	Determining whether stormwater pathway PFAS loads are large or small relative to other pathways for PFAS to reach the Bay will inform stakeholder prioritization of potential PFAS management strategies.
3) What are the physical, chemical, and biological processes that may affect the transport and fate of individual CECs or groups of CECs in the Bay?	N/A	
4) Have the concentrations of individual CECs or groups of CECs increased or decreased in the Bay?	N/A	
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	
6) What are the effects of management actions?	N/A	

Approach

The proposed project includes multiple elements, all of which are necessary to develop a robust, practical, and cost-effective PFAS-specific stormwater monitoring study design to answer the near-term priority management question of whether the local watershed PFAS runoff load to San Francisco Bay is big or small as compared to loads from other pathways.

One group of project elements implements a key part of the new stormwater CECs approach: integrating modeling into monitoring design. This is accomplished by (1) developing a preliminary conceptual model for PFAS in urban runoff; (2) evaluating the data needs for first-order loads estimation modeling via analysis of prior RMP PFAS monitoring data; (3) filling out the SFEI stormwater sampling site database to include sites and site characteristics needed for PFAS monitoring site selection based on the conceptual model; and (4) using watershed modeling data needs in combination with the conceptual model to select monitoring locations for the PFAS study design. The load modeling needs will flow from the watershed model selected for this purpose, which will be identified through the separate RMP CEC Stormwater Loads Modeling Exploration project (led by SPLWG), anticipated to be completed in 2022.

A second group of project elements is aimed at developing a practical, cost-effective method for remotely collecting stormwater samples. Remote sampler capabilities reduce collection costs and make it possible to obtain many more samples per storm event than is possible with current manual sampling techniques. Having this capacity will shorten the time frame necessary to address CECs management questions requiring stormwater monitoring data. These project elements include (1) developing a limited study design to pilot and evaluate remote samplers for usability for PFAS sampling; (2) selecting and piloting specific remote samplers and conducting QA/QC testing of the samplers to evaluate potential for sample contamination; and (3) completing associated PFAS chemical analysis, data interpretation, data management, and QA review.

Finally, the project will conclude with preparation of a report outlining a PFAS monitoring study design that could be implemented as soon as WY 2024.

<u>Integrating modeling into monitoring design</u>

Preliminary conceptual model

The purpose of this task is to build a preliminary conceptual model that synthesizes and integrates our current understanding of PFAS sources and pathways to urban runoff to inform monitoring design. PFAS sources will be identified through a literature review and the possible collaboration with the University of Toronto/GSPI building materials project, with a focus on true sources, i.e., products or activities that provide a pathway for release of PFAS into the outdoor urban environment. The conceptual model will focus on probable major sources only. It will include limited consideration of fate and transport, drawing from prior published conceptual models (e.g., Prevedouros et al. 2006, De Silva et al. 2021). A conceptual model diagram will identify the pathways for PFAS to be transported from these sources, via urban runoff only, into San Francisco Bay, with the intent of providing information sufficient to inform the initial monitoring design. The diagram and brief description will be part of the study design report.

In the future, a more detailed conceptual model beyond the scope of the proposed effort could be developed to aid data interpretation or update the study design to address future management questions (e.g., linkages to specific PFAS sources or understanding how PFAS transformation affects transport or loads in stormwater entering the Bay).

Analysis of prior PFAS monitoring data to inform monitoring design

The PFAS monitoring data previously mentioned, coupled with geospatial data (e.g., land use, road map, imperviousness), provide an initial dataset for assessing sample variability. The data analysis will provide a general picture of existing monitoring data and a rough estimation of sources of variability in the monitoring data. By exploring the variability between samples collected at the same location and between samples collected at different locations, the data analysis can further guide monitoring approaches. For example, the analysis can help us answer the following questions: What is the variability between samples at the same location and at different locations? Are there any linkages between variability and geospatial features? Assessing monitoring data variability can address some key monitoring design questions, such as how many replicates are needed for a sampling site and how many sites are required for load estimation purposes. From a modeling point of view, which monitoring locations are suitable for load monitoring and which are suitable for identifying PFAS sources? These types of questions will be addressed in the study design report.

Sampling location database

Typically for past RMP stormwater monitoring, sites have been selected each year in collaboration with the Small Tributaries Loading Strategy (STLS) team, a subgroup to the Sources Pathways and Loadings Workgroup composed of RMP staff, Water Board staff, and Permittee representatives. Site selection priorities have focused on characterizing Hg and PCBs in stormwater runoff in the Bay Area, and identifying sites that may be higher-leverage watersheds for potential follow-up management actions.

A moderate effort is required each year to develop new potential sampling site lists and assess these sites for safety, feasibility, and land use characteristics. While the current process has been effective, it has not been structured and archived consistently from year to year, nor are sites that are relevant to characterizing and identifying high-leverage watersheds for Hg and PCB management action necessarily the same as those ideal for characterizing PFAS, or other CECs, in urban runoff.

To select sites for the most effective and efficient monitoring design for PFAS and CECs, both in the current proposal and future monitoring programs, we must develop an organized sampling location database that includes pertinent information that would be relevant to sampling various CECs. RMP staff have begun developing this sampling location database through funding from the Stormwater CECs Monitoring Strategy project, including gathering lists of sites sampled by the USGS, Water Board, municipalities, and SFEI. We have also solicited information on potential sampling locations from the Permittees. In this task, we propose to fill out the SFEI stormwater sampling site database to include sites and site characteristics needed for PFAS monitoring site selection based on the conceptual model. This will first focus on characterizing sites that have flow gauging (beneficial data for modeling purposes), and then look more broadly at sites that do not have flow gauging. The effort includes compiling the existing site lists; potentially developing new datasets on land use attributes that support site selection for PFAS monitoring; and conducting reconnaissance of these sites to assess sampling feasibility using a variety of sampling techniques.

<u>Remote samplers - pilot stormwater sampling and evaluation</u>

Remote sampler selection

RMP scientists intend to pilot two very different remote stormwater samplers. The USEPA has developed an in-stream remote sampling device (Kahl et al., 2014) that collects whole water samples using a micropump. The EPA is collaborating with the USGS, which is starting the process of modifying the current sampler to include telemetry and stage-measurement capabilities. We are currently in discussion with the EPA and USGS and it is likely that we would be able to pilot these samplers in the Water Year 2023 wet season (begins October 2022).

In addition to pilot testing the EPA/USGS samplers, we would also test traditional automated pumping samplers, specifically drawing upon samplers we already have in-house (ISCO, model 6712). These samplers are placed on the side of the channel with tubing extending into the channel. This traditional sampling approach is well-proven and may be needed if the EPA/USGS samplers do not prove workable for PFAS (e.g., if they have unacceptable levels of blank contamination). Deployment of the ISCO samplers is anticipated to be more labor-intensive (securing the conduit and tubing in the channel, housing the ISCO or leaving it outside a lock box, which leaves it vulnerable to vandalism) and overall more expensive (due to the cost of the sampler, tubing and cleaning costs for the tubing, as well as a more intensive effort to deploy) than the EPA/USGS samplers.

In both cases, several blank samples will be collected and analyzed to ensure the equipment does not influence the PFAS concentrations in the samples.

Pilot stormwater sampling
A limited pilot study design, including site selection, sample analysis methods, and finalization of field methods will be developed by RMP staff in consultation with ECWG and SPLWG advisors as well as reviewed by Dr. Erika Houtz, an expert in PFAS sampling and analysis.

Pilot site selection will occur in consultation with the RMP stormwater team and the STLS team. Sites will be selected from the compiled site location database. Pilot site selection will be informed by the parallel modeling efforts to the extent feasible.

Up to 20 pilot project samples (including several field blank and several field duplicate samples) will be collected. Sample collection will include limited field deployment (up to four sites) as the primary focus will be on method development and QA samples such as equipment blanks, field blanks, and field duplicates. Field samples will consist of flow-weighted composites collected using the two different remote samplers (previously described) deployed side-by-side. Other tasks required for stormwater sampling include: securing permits, training staff, pre-season and pre-storm preparation, the deployment and retrieval of samplers, shipping bottles to laboratories, and cleaning equipment.

Chemical analysis, data management and QA, and data interpretation
Up to 20 samples will be characterized by SGS AXYS Analytical Laboratories, Inc. for target PFAS, PFAS Total Oxidizable Precursors (TOP), and adsorbable organic fluorine (AOF). All analytical methods are also being applied to Bay Area wastewater samples through an ongoing BACWA study. The sample number includes collection at up to four sites around the Bay Area, equipment blank samples, field blank samples, and field duplicates.

For target PFAS[1] analysis, after spiking with isotopically labeled surrogate standards, samples are extracted and cleaned up by Solid Phase Extraction (SPE). The extracts are then analyzed by liquid chromatography/mass spectrometry (LC-MS/MS). Final sample concentrations are determined by isotope dilution/internal standard quantification.

Analysis of Total Oxidizable Precursors (TOP) measures oxidizable polyfluoroalkyl substances (PFAS) converted into terminal perfluorinated carboxylic acids (PFCAs) through the use of persulfate oxidation and subsequent analysis of perfluorinated carboxylates (C4-C14) and sulfonates (C4-C10, C12). The increase in concentration of the terminal carboxylic acids following oxidation represents the precursor potential of the sample.

The determination of adsorbable organic fluorine (AOF) is applicable to aqueous samples including water, wastewater, and diluted products. This analysis is proposed here to evaluate it as a potential element of the stormwater PFAS study design and for comparison to similar measurements being conducted at Bay Area municipal wastewater treatment plants. The method targets compounds that are adsorbed onto activated carbon. After passing the sample through an activated carbon column, the carbon containing the adsorbed organic material is rinsed with neutral nitrate solution to remove inorganic fluorine salts and then subjected to the combustion process and ion chromatographic determination of the fluoride in the sample.

Data management and QA will include field collection data entry, communications with laboratories, quality assurance review and upload to CEDEN of target PFAS concentrations (as appropriate).

Data interpretation will include evaluating samplers for potential contamination and examining pilot data in the context of other PFAS work (including the similar measurements underway at Bay Area municipal wastewater treatment plants) to inform selection of monitoring methods for the study design. These tasks will be completed by RMP staff in consultation with Dr. Erika Houtz.

The overall experiences with the samplers and the chemical analysis data, particularly the blank samples, will be evaluated in the study design report as input to the selection of the sampling and chemical analysis approach in the stormwater PFAS study design.

Stormwater PFAS monitoring study design

A draft report presenting a study design for monitoring PFAS in stormwater will be prepared on the basis of the project elements above. Watershed modeling data needs in combination with the conceptual model will be used to select monitoring locations. The pilot sampler experience will determine the selection of the sampling methods and analytical techniques. The study design report will include the outcomes of each of the above project elements.

[1]Anticipated analysis includes: perfluoroalkyl carboxylates (11 compounds including PFOA), perfluoroalkyl sulfonates (eight compounds including PFOS), fluorotelomer sulfonates (three compounds), fluorotelomer carboxylates (three compounds), perfluorooctane sulfonamides (three compounds), perfluorooctane sulfonamidoacetic acids (two compounds), perfluorooctane sulfonamidoethanols (two compounds), ether carboxylates (five compounds), and ether sulfonates (three compounds).

During the study design development, we will also explore potential collaboration with SWAMP SPoT, which is planning sediment PFAS monitoring at four Bay Area creek locations, and collaboration with the University of Toronto/GSPI building materials PFAS project.

Budget

Table 2. Proposed Budget

Expense	Estimated Hours	Estimated Cost
Labor		
Conceptual Model, Analysis of Prior PFAS Monitoring Data to Inform Design, Sampling Location Database	366	61,000
Remote Sampler Development and Pilot Stormwater Sampling	296	45,000
Data Interpretation	30	7,000
Data Technical Services	76	12,000
Study Design Report	100	20,000
Subcontracts		
PFAS, TOP Assay, and AOF: SGS AXYS		22,000
Honorarium		2,000
Direct Costs		
Equipment		9,800
Travel		400
Shipping		800
Grand Total		**180,000**

<u>Budget Justification</u>

SFEI Labor

Labor hours are estimated for SFEI staff to complete all project elements: developing a preliminary conceptual model for PFAS in urban runoff; evaluating the data needs for first-order loads estimation via analysis of prior RMP PFAS monitoring data; filling out the SFEI stormwater sampling site database to include sites and site characteristics needed for PFAS monitoring site selection; developing and piloting remote samplers for CECs sample collection; developing a limited study design to pilot sampling methods; data interpretation; and preparation of the PFAS monitoring study design and report. SFEI will also work internally and with potential USGS collaborators to design remote samplers and then pilot test their deployment during storm events.

Laboratory Costs
The analytical laboratory is receiving a budget sufficient to analyze up to 20 samples. Laboratory QA/QC samples will be analyzed at no charge, while equipment blanks, field blanks, and field duplicates will be considered part of the 20 samples charged to the RMP.

Data Technical Services
Data services will include field collection data entry, communications with laboratories, quality assurance review following standard RMP data management protocols and data upload of target PFAS concentrations to CEDEN.

Reporting

A presentation in Spring 2023 will update the ECWG and SPLWG. The primary focus of reporting will be on developing the draft study design by Fall 2023 (final study design report due December 2023), for potential use in WY2024.

References

De Silva, A., Armitage, J., Bruton, T., Dassuncao, D., Heiger‐Bernays, W., Hu, X., Kärrman, A., Kelly, B., Ng, C., Robuck, A., Sun, M., Webster, T., & Sunderland, E. (2021). PFAS Exposure Pathways for Humans and Wildlife: A Synthesis of Current Knowledge and Key Gaps in Understanding. Environ Toxicol Chem, 40, 631–657.

Kahl, M.D., Villeneuve, D.L., Stevens, K., Schroeder, A., Makynen, E.A., Lalone, C.A., Jensen, K.M., Hughes, M. Holmen, B.A., Eid, E., Durhan, E.J., Cavallin, J.E., Berninger, J., and Ankley, G.T. 2014. An inexpensive, temporally integrated system for monitoring occurrence and biological effects of aquatic contaminants in the field. Environmental Toxicology and Chemistry, Vol. 33, 7, pp 1584-1595.

Prevedouros K., Cousins I.T., Buck R.C., Korzeniowski S.H. 2006. Sources, fate and transport of perfluorocarboxylates. Environmental Science & Technology 40:32-44.

Sedlak, M.D., Benskin, J.P., Wong, A., Grace, R., Greig, D.J., 2017. Per- and polyfluoroalkyl substances (PFASs) in San Francisco Bay wildlife: Temporal trends, exposure pathways, and notable presence of precursor compounds. Chemosphere 185, 1217–1226. https://doi.org/10.1016/j.chemosphere.2017.04.096

Sedlak, M., Sutton, R., Wong, A., Lin, D. 2018. Per and Polyfluoroalkyl Substances (PFAS) in San Francisco Bay: Synthesis and Strategy. SFEI Contribution No. 867. San Francisco Estuary Institute : Richmond, CA. https://www.sfei.org/documents/and-polyfluoroalkyl-substances-pfass-san-francisco-bay-synthesis-and-strategy

SPLWG Special Study Proposal: Tidal Area Sampling Remote Sampler Development and Pilot Testing

Summary

Old industrial land use is the main source of the greatest yields as well as total mass of PCB loads in the Bay Area. Provisions C.11.c and C.12.c of the revised tentative order of the Municipal Stormwater Regional Permit (MRP) call for control measure implementation in old industrial areas. However, we have been unable to sample stormwater runoff from much of this area. Greater than 50% of the old industrial landscape in the Bay Area lies within 1 km of the Bay and is often tidally influenced. Such sites are difficult to sample, requiring stormwater runoff during a very low tide to avoid sampling Bay water. Furthermore, these areas often have public access limitations. In this study, we propose to modify and field test an EPA-developed remote sampler coupled with an auto-logging micro salinity probe that we can anchor in the water column in tidally influenced areas receiving stormwater runoff from old industrial areas. The sampling equipment would be installed just prior to a storm and retrieved after. The salinity probe will be used to control the sampling to ensure samples contain mostly fresh stormwater. Samples would be analyzed for total PCBs, total Hg, and suspended sediment. The primary focus in this first year is on modification of the samplers and pilot testing at up to four field sites, with field replicates and blanks tested at every site. Prior to the first field deployment, two blanks will be collected in the SFEI laboratory to ensure the equipment does not cause contamination. Once the EPA-sampler is successfully modified and piloted, it could be used to help identify which tidally influenced industrialized drainage areas on the Bay margin could be prioritized for management consideration. The deliverable of this project would be quality assured PCB and Hg data made available through the CD3 web tool, and a short report detailing the methods and results of the pilot study. This is primarily a field study and the level of effort will be tailored to the amount of budget available. There is no phasing proposed.

Estimated Cost: $85k
Oversight Group: STLS/SPLWG
Proposed by: A Gilbreath, D Yee, and L McKee (SFEI)
Time Sensitive: No.

Proposed Deliverables and Timeline

Deliverable	Due Date
Development/selection/modification of remote sampler	12/2022
Pilot testing during rainy season	04/2023
Update presentation at SPLWG on the results to date	05/2023
Data upload to CEDEN	12/2023
Report (draft and final)	1/2024

Background

Old industrial land use is the main source of the greatest yields and total mass of PCB loads in the region (Wu et al., 2017), but at this time due to sampling logistics, only the non-tidal portions of this land use have been well sampled (Gilbreath and McKee, 2022). Consistent with the previous stormwater permit (SFRWQCB, 2015), provisions C.11.c and C.12.c of the revised tentative order of the MRP call for Control Measure Implementation in old industrial areas totaling 8% of the remaining untreated or not redeveloped area over the next permit term (SFRWQCB, 2022). But a large percentage of the Bay Area's heavy industrial land uses that were historically serviced by rail and ship-based transport are located in close proximity to the shoreline. These areas are very difficult to sample because of a lack of public right-of-ways. In addition, a range of tidal-related constraints near the Bay such as bidirectional flow, the timing of tides with storms, the need for boat access to outfalls to install equipment and take samples, complex mixing, and water column stratification make sampling these areas challenging. Yet, there is a clear need to sample these old industrial land use areas more thoroughly, as we hypothesize they likely produce a large portion of the regional PCB loads. Such sampling could help identify particularly highly polluting properties and drainages for management investigation and potential action.

To date, the RMP has sampled stormwater from nearly 100 watersheds and drainages in the region. **However, sampling for PCBs and HgT since WY 2003 has included just 34% of the old industrial land use in the region.** The best coverage to date has occurred in Santa Clara County (78% of old industrial land use in the county is in watersheds that have been sampled), followed by San Mateo County (36%) and Alameda County (32%). In Contra Costa County, only 16% of old industrial land use is in watersheds that have been sampled, and just 1% in Solano County. The disproportional coverage in Santa Clara County is a result of sampling several large watersheds (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek and San Tomas Creek) that have relatively large proportions of older industrial land use upstream from their sampling points. **Of the *remaining* older industrial land use yet to be sampled across all the counties, 48% of it lies within 1**

km and 74% within 2 km of the Bay. These areas are more likely to be tidally influenced and are often not well serviced by public roads.

With great patience and effort, some sampling in tidally influenced areas has occurred during the last seven years. To be able to sample these areas, tides that are sufficiently low (site-dependent) and long (minimum approximately 3 hours) must align with storms of sufficient intensity. Tidal sites get the highest priority during each storm event in which these requirements are met, but such opportunities have been rare. For several years, the POC reconnaissance report stated: “A different sampling strategy may be required to effectively assess what pollution might be associated with these areas and to better identify sources for potential management” (Gilbreath and McKee, 2022).

In addition, as noted in a complementary proposal to develop a remote sampler suitable for CECs sampling, one of the largest costs of stormwater sampling is the labor associated with two staff per site being out in the field for an extended period during storms. Over the years, we have found ways of reducing this cost by alternating sampling between two field locations that are near each other during a storm, addressing the needs of multiple work groups by taking samples for a greater number of pollutants, and developing a remote sediment sampler that allows staff to be absent during the storm (Gilbreath et al., 2019). However, the remote sediment samplers cannot be used in tidal areas because of the challenge of deploying and retrieving a sampler *all within one low-tide window*, so as to minimize sampling Bay (non-stormwater) suspended sediment. Even if such a sample was collected, without some measurement of the freshness of the water during collection, there would be no way of knowing what proportion of stormwater or Bay water was sampled.

In this study, we propose to develop a second-generation, active remote sampling method for tidal areas such that staff need not be present, the samplers can be deployed and retrieved during higher tides, and although the samplers may be inundated at times with tidal waters, a salinity sensor will trigger the sampler only during low salinity periods when urban stormwater is dominant. An additional benefit of this type of active remote sampler is the ability to collect whole water samples for CECs or other pollutants which might be found partially or primarily in the dissolved phase. This study will help to identify industrialized or other urban drainage areas on the Bay margin for management consideration that we have otherwise been unable to sample, thus providing a much-needed new tool for stormwater managers.

Study Objectives and Applicable RMP Management Questions

The goal of this project is to choose, develop/modify, and pilot field test a remote sampler for sampling in tidal areas that would include three basic elements:

- the ability to be deployed and left unattended in a tidal area throughout a storm event,
- the ability to collect whole water samples, and
- the ability to collect continuous salinity measurements and trigger the sampler only when salinity is low.

The near-term objectives of the sampling approach will be to (a) choose and modify, or create, a remote sampler that can be left unattended in a tidal reach, (b) connect a salinity sensor with data logging capability for continuous measurement during deployments and the ability to program the sampler to collect samples only when low salinity is measured, (c) deploy and pilot field test the remote samplers during storm events at two to six sites (depending on available funding due to efficiencies/unforeseen challenges in development of the sampler, the number of samplers we can build (whether one or two), and the number of storms available for sampling in WY 2023.

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

Management Question	Study Objective	Example Information Application
Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay?	Develop a remote sampler to collect POC data in tidal areas that we have previously been unable to sample due to tidal constraints.	What are the concentrations of POCs downstream of industrialized areas close to the Bay margin?
Q2: Which are the “high-leverage” small tributaries that contribute or potentially contribute most to Bay impairment by POCs?	Indirect, via answering Q1	Identify high leverage drainages to sensitive Bay margins downstream of tidally influenced industrial areas.
Q3: How are loads or concentrations of POCs from small tributaries changing on a decadal scale?	N/A	N/A
Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff?	Indirect, via answering Q1	Confirm/refute if high PCB concentrations are found downstream of suspected PCB source areas.
Q5: What are the measured and projected impacts of management action(s) on loads or concentrations of POCs from small tributaries, and what management action(s) should be implemented in the region to have the greatest impact?	N/A	N/A

Approach

EPA has developed and successfully used over 100 times a remote, micro-pump sampler (Kahl et al., 2014) that would be a suitable sampler to modify for our purposes. In fall and winter of 2022/2023, the USGS will collaborate with EPA to further expand the capabilities of this sampler by including telemetry and stage logging capabilities. Our approach will be to evaluate this sampler and modify it to add or exchange salinity logging with stage logging. If we are successful in modifying the sampler, we will conduct a field trial that will include deploying these remote samplers at as many locations as possible (minimum of two) depending on the amount of funding available. In this study, we will utilize a low draft boat or other means to access tidal sites downstream from heavy industrial areas. There we would anchor a coarse-screened micro-pump sampler and an auto-logging micro salinity probe in the water column. The sampling equipment would be installed just prior to a storm and retrieved after. The whole water sample would be analyzed for suspended sediment, PCB and Hg concentrations.

Budget

The following budget represents estimated costs for this special study (Table 2). This study is scalable.

Table 2. Proposed budget.

Expense	Estimated hours	Estimated Cost
Labor		
Project Staff	200	$36,000
Project Management	32	$6,000
Data Management	40	$6,000
Reporting	60	$12,000
Subcontracts		
SGS AXYS Analytical, Brooks Applied Laboratories, USGS		$14,700
Direct Costs		
Equipment		$6,000
Travel		$500
Shipping		$3,800
Grand Total	332	**$85,000**

Budget Justification
Labor Costs: 332 hours of staff time to research and develop/modify the remote sampler, deploy the sampler, analyze the data, and present to SPLWG in spring 2023.

Early Funds Release Request
If this project is approved, we request early release of funds for use in 2022. We would develop this remote sampler in Water Year 2023 (which begins fall of 2022). Therefore, we must begin identification and modification of the remote sampler in summer 2022.

Reporting

The data for the remote sampler will be presented to SPLWG in the spring of 2023. Additionally all data will be uploaded to CEDEN and a short technical report (draft and final) will detail the methods and a brief presentation of the results.

References

Gilbreath, A.N., Hunt, J.A., Yee, D., and McKee, L.J., 2019. Pollutants of concern (POC) reconnaissance monitoring final progress report, water years (WYs) 2015 - 2018. A technical report prepared for the RMP, SPLWG, STLS. Contribution No. 942. SFEI, Richmond, CA. https://www.sfei.org/documents/pollutants-concern-reconnaissance-monitoring-water-years-2015-2018

Gilbreath, A.N., and McKee, L.J., 2021. Pollutants of Concern Reconnaissance Monitoring Progress Report, Water Years 2015-2020. SFEI Contribution #1061. San Francisco Estuary Institute, Richmond, California. https://www.sfei.org/documents/pollutants-concern-reconnaissance-monitoring-progress-report-water-years-2015-2020

Kahl, M.D., Villeneuve, D.L., Stevens, K., Schroeder, A., Makynen, E.A., Lalone, C.A., Jensen, K.M., Hughes, M. Holmen, B.A., Eid, E., Durhan, E.J., Cavallin, J.E., Berninger, J., and Ankley, G.T. 2014. An inexpensive, temporally integrated system for monitoring occurrence and biological effects of aquatic contaminants in the field. Environmental Toxicology and Chemistry, Vol. 33, 7, pp 1584-1595.

SFRWQCB, 2015. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order No. R2-2015-0049, NPDES Permit No. CAS612008. November 19, 2015. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/R2-2015-0049.pdf

Wu, J., Gilbreath, A.N., McKee, L.J., 2017. Regional Watershed Spreadsheet Model (RWSM): Year 6 Progress Report. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 811. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/regional-watershed-spreadsheet-model-rwsm-year-6-final-report

SPLWG Special Study Proposal: Regional Model Development to Support Assessment of Watershed Loads and Trends (Pilot POC modeling phase 2)

Summary

The RMP's 2018 Modeling and Trends Strategy prioritized further assessment of the regional estimates and temporal trends in contaminant loads from watersheds, and developed a multi-year plan for model development. Although initially conceived as a tool for evaluating only PCB and Hg trends, advice provided at the May 2019 RMP Sources, Pathways, and Loadings Work Group (SPLWG) meeting caused the RMP to broaden the modeling work plan to include support for better estimates of loads of sediment and other contaminants, such as contaminants of emerging concern (CECs), in addition to PCBs and Hg. The two main objectives of the pollutant of concern (POC) model development are to: 1) create a flexible watershed modeling platform for general contaminant simulation; and 2) answer management questions related to PCBs, Hg, sediment, and (in the future) contaminants of emerging concern (CECs). This proposal is for funding in 2023 for phase 2 of the contaminant modeling. Phase 1 of the POC modeling, currently in progress, is developing a flexible modeling framework to quantify stormwater flow, sediment, and contaminant baseline loads at both watershed and regional scales, using PCBs and Hg as pilot examples. Phase 2 will focus on setting up a modeling framework for evaluating the benefits of control measures and developing a web-based data sharing platform. We also propose three meetings with key stakeholders to get input on model data needs and assumptions, interim model review, and model final review. The developed model structure will be a basis for and further modified for other contaminants in the future. Trends associated with control measures, land-use and climate change, or other scenarios could then be explored.

Estimated Cost: $130K
Oversight Group: STLS/SPLWG
Proposed by: Tan Zi, David Peterson, Alicia Gilbreath, and Lester McKee (SFEI)
Time Sensitive: Yes - this is phase 2 of a two-year POC pilot modeling study

Proposed Deliverables and Timeline

Deliverable	Completion Season
Model data collation and preparation	Summer 2023
Control measures impact estimation	Fall 2023
Draft modeling report for peer review	Fall 2023
Final modeling report and data sharing portal	Winter 2023

Background

The San Francisco Bay TMDLs call for a 50% reduction in Hg loads by 2028 and a 90% reduction in PCB loads by 2030, respectively. To implement these TMDLs, the Municipal Regional Permit for Stormwater (MRP) (SFRWQCB, 2009; 2015; 2022) called for the implementation of control measures to reduce PCB and Hg loads from urbanized tributaries. In addition, the MRP has identified additional information needs associated with improving understanding of sources, pathways, loads, trends, and management opportunities for contaminants. In response to the MRP requirements and information needs, the Small Tributary Loading Strategy (STLS) was developed, outlining a set of management questions (MQs) that have been used as the guiding principles for the region's stormwater-related activities (Table 1; SFEI, 2009; Wu et al., 2018).

Over the past decade, the RMP Sources, Pathways, and Loadings Workgroup (SPLWG) and Bay Area Municipal Stormwater Collaborative (BAMSC) have focused on getting answers to MQ1, MQ2, and MQ4 in relation to PCBs and Hg. In recognition of the need to answer MQ3, the STLS team updated the Strategy in 2018 to include a trends component, mainly for PCBs. The new Modeling and Trends Strategy identified the development of a regional watershed dynamic model as a priority, with an initial focus on PCB and Hg loading, but developed in a way that would facilitate its use for evaluation of trends.

Although there is a more general objective to support multiple pollutants, initially the model will be developed for PCBs and Hg simply because we have the most loading data for these pollutants. In the case of PCBs, with a reevaluation of the PCBs TMDL planned for 2028, a new robust estimate of PCB load and trends is needed to link management effort with load reduction progress and to link to the enhanced in-Bay fate modeling that is also being conducted under the PCB workgroup. Future applications of the regional model could also be developed to include other pollutants, such as individual contaminants of emerging concern (CECs) and nutrients, and provide a mechanism for evaluating the potential for management actions and management impact on future pollutant loads or concentrations in support of MQ5.

As shown in Table 2, the 2018 Modeling and Trends Strategy included a multi-year work plan that would obtain initial answers to loading questions by 2022, and the trends or other questions in years beyond with additional funding. The first step of this plan, completed in 2019, was to develop a Modeling Implementation Plan (MIP) to guide model development, which included model platform selection and development procedures and a timeline (Wu and McKee, 2019). Subsequently, RMP funding for 2020 and 2021 supported hydrologic and sediment watershed model setup and calibration, which have been completed (Zi et al., 2021, 2022 [in review]. The baseline load modeling of PCBs and Hg (Pilot POC modeling phase 1) is expected to be completed by the end of 2022. This proposal is for 2023 funding to implement the phase 2 of the pilot POC modeling, which includes setting up the control measures module of WDM for PCBs and Hg, and evaluating the impacts of control measures on load reduction at regional scale.

Study Objectives and Applicable RMP Management Questions

This study will provide the ability to understand the impact of control measures on contaminant load reduction, at the scales of both individual watersheds and the region as a whole in relation to the SPLWG high-level management questions. Assessing the impacts of control measures with WDM at the regional scale could help address the SPLWG's management questions 3 and 5 and, in the case of PCBs, in support of the planned 2028 TMDL update. By setting up the modeling framework for control measures estimation, the WDM would be able to evaluate the effectiveness of management actions and the long-term trend of contaminant loads given the historical control measure records and future management scenarios in the context of a variable and changing climate.

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

Management Question	Study Objective	Example Information Application
Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay?	Complete the control measures modeling module for PCBs and Hg to support load and trends evaluation. Provide a modeling platform that could be modified for individual CECs modeling. Provide a modeling platform for management action scenarios test and evaluation.	The model will produce an estimate of PCBs and Hg concentrations and loads at each individual watershed.
Q2: Which are the "high-leverage" small tributaries that contribute or potentially contribute most to Bay impairment by POCs?		Estimates produced by the regional model at each individual watershed can be compared to explore relative loading rates and how those pass into specific priority margin areas, operational landscape units, or RMP Bay segments.
Q3: How are loads or concentrations of POCs from small tributaries changing on a decadal scale?		Support for the 2028 PCB TMDL update. 1. Provide a new robust estimate of watershed PCB loads to the Bay. 2. The load reductions from control measures could be estimated via the control measure module and can be used to assess trends for individual watersheds and the region as a whole.
Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff?		Model outputs of PCBs and Hg will help identify high yield areas that can be targeted for management actions.
Q5: What are the measured and projected impacts of management action(s) on loads or concentrations of POCs from small tributaries, and what management action(s) should be implemented in the region to have the greatest impact?		Management actions, both existing and planned or anticipated, could be evaluated in the model through scenario runs. This could be used to support the 2028 PCB TMDL reevaluation by providing a reasonable assurance prediction of likely future load reductions with further management effort.

Approach

A phased approach is being employed to develop the regional model, starting with hydrology, followed by suspended sediment, and then contaminants. Table 2 lays out the roadmap for the whole project from inception (2015) through to the end of the multi-year plan as it currently stands. The tasks proposed represent phase 2 of pilot POC modeling and will primarily cover development of the control measure modeling module, and estimate the impacts of control measures on the loads of PCBs and Hg.

To estimate the impact of control measures on the contaminant load, we will gather GSI data for the region. We will begin with data already compiled at the county level, and develop a framework for converting these data to metrics to be used in the WDM. We will develop a standardized regional GSI data layer. The load reduction simulation of other control measures, such as source control, will be based on the methods developed by RAA modeling projects (ACCWP 2020, CCCWP 2020) and summarized at the regional scale.

Table 2. Timeline and budget ($k) for major milestones of the modeling multi-year plan.

Year	Cost ($k)	Deliverable	Completion Season
2015 - 2018	235	Loads and trends strategy conception; Conceptual model development for PCBs and Hg; Statistical analysis of PCB trends in Guadalupe River; Completion of Small Tributaries Loading Strategy: Modeling and trends Strategy.	2018
2019	60	Modeling Implementation Plan	2019
2020	100	Hydrology calibration completed	2020
2021	150	Sediment model calibration completed and report	2022
2022	90	Proof of concept model (PCBs and Hg): Baseline load modeling	Dec-2022
2023	45	Proof-of-concept model preparation using the best available datasets (PCBs and Hg): Control measures modeling setup and preliminary data collection, stakeholder discussion meeting	Summer 2023
	50	POC model extension to incorporate new monitoring data. Control measures modeling and stakeholder discussion meeting	Fall 2023
	35	Modeling report, stakeholder review meeting, and data sharing portal with the objective of making the model publically available, gathering user experience, and planning for other pollutants.	Winter 2023
Future		Model refinement and application runs for answering RMP questions including: 1. 2027: Model recalibration and refinements with more available monitoring data to support PCB TMDL 2028 reevaluation. 2. Model refinements for assessing trends-associated control measure	Not yet proposed

		implementation and land use change 3. Model development for other contaminants such as one or more CECs 4. Linking and doing model runs to support models of physical and biological processes on the Bay margins or in the Bay	

Budget

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

Table 3. Proposed budget.

Expense	Estimated Hours 2023	Estimated Cost ($)
Project Staff (Modeling)	300	$45,000
RMP staff and stakeholder interactions, three discussion meetings, and SPLWG review	110	$20,000
Data technical services (monitoring data process, control measure data gathering and process, modeling input data preparation, etc.)	260	$30,000
GIS services	80	$10,000
Reporting	180	$25,000
Total	***930***	***$130,000***

<u>Budget Justification</u>

Labor Costs: Staff support to gather available GSI data for the region, develop a standardized data format, develop scripts to convert data into a standard format, and prepar a regional GSI data layer. It will also support staff time to perform calibration/verification, process model results, and write up technical reports; collect and process GIS data and construct a webpage; consult on water quality and control measure data and get technical support from related other parties; and senior staff contributions and review.

Reporting Costs: RMP staff will produce a model report to document all aspects of model development, including input data, key assumptions, calibration/verification, and model results.

Reporting

- Annual Model Development presentations to STLS and SPLWG will be prepared.
- Three presentations and related modeling materials for discussion meetings with key stakeholders.
- A regional GSI data layer.
- Draft modeling report for peer review.
- Final modeling report.
- Data and modeling results will be made available for the public.

References

ACCWP, 2020. Alameda County PCBs and Mercury TMDL Control Measure Plan and Reasonable Assurance Analysis Report.

CCCWP, 2020. Contra Costa County PCBs and Mercury TMDL Control Measure Plan and Reasonable Assurance Analysis Report.

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/index.shtml

SFRWQCB, 2015. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order No. R2-2015-0049, NPDES Permit No. CAS612008. November 19, 2015. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/R2-2015-0049.pdf

SFRWQCB, 2022. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Revised Tentative Order No. R2-2022-XXXX, NPDES Permit No. CAS612008. May 11, 2022. https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/MRP/mrp5-22/MRP_3_Revised_Tentative_Order.pdf

Wu, J., Trowbridge, P., Yee, D., McKee, L., and Gilbreath, A., 2018. RMP Small Tributaries Loading Strategy: Trends Strategy 2018. Contribution No. 886. San Francisco Estuary Institute, Richmond, CA. https://www.sfei.org/sites/default/files/biblio_files/STLS%20Trends%20Strategy%202018%20FINAL.pdf

Wu, J., and McKee, L.J., 2019. Modeling Implementation Plan-Version 1.0. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Contribution No. 943 San Francisco Estuary Institute, Richmond, California. https://www.sfei.org/documents/regional-watershed-model-implementation-plan

Zi, T., McKee, L., Yee, D., Foley, M., 2021. San Francisco Bay Regional Watershed Modeling Progress Report, Phase 1. Report prepared for the Sources Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality. SFEI Contribution No.1038. San Francisco Estuary Institute, Richmond, CA.
https://www.sfei.org/documents/san-francisco-bay-regional-watershed-modeling-progress-report-phase-1

Zi, T., Braud, A., McKee, L., Yee, D., Foley, M., 2022. San Francisco Bay Regional Watershed Modeling Progress Report, Phase 2. Report prepared for the Sources Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality. SFEI Contribution No.xxxx. San Francisco Estuary Institute, Richmond, CA (in review).

SPLWG Special Study Proposal: CEC stormwater load modeling

Summary

Previous studies provide evidence that stormwater is a major pathway for contaminants of emerging concern (CECs) to enter San Francisco Bay. Building upon the CECs watershed modeling roadmap being created by the RMP 'Integrated watershed modeling and monitoring implementation strategy' project (funded in 2021), and the 'CEC stormwater load modeling exploration' project (funded in 2021), this project will develop screening-level estimates of stormwater CEC loads. PFAS were selected for this pilot project based on their status as a Moderate Concern CEC in the RMP tiered, risk-based framework for prioritizing CECs, high priority at the state level, and stakeholder interest based on past projects. Some current and parallel projects, 'Stormwater Contaminants of Emerging Concern (CECs) Monitoring Strategy (Year 2)' (proposed to ECWG for 2023) and 'CECs in Stormwater: PFAS' (proposed to ECWG for 2023) will provide more PFAS monitoring data and develop a conceptual model for the PFAS sources and pathways, which are necessary information for PFAS load estimation. The specific goals of this study are: (1) to develop an approach for screening-level stormwater loading estimation for one or more individual PFAS, such as PFOS or PFOA, (2) to pilot a load estimation approach that can be used/adjusted in modeling other priority stormwater CECs in the context of specific physico-chemical properties, sources, transport pathways, and fate, (3) to identify data gaps and needs from a modeling perspective to inform the two ECWG proposed studies: 'Stormwater Contaminants of Emerging Concern (CECs) Monitoring Strategy (Year 2)' and 'CECs in Stormwater: PFAS', as well as future monitoring designs for PFAS and other CECs. This load estimation study will address both SPLWG and ECWG management questions.

Estimated Cost: $100K
Oversight Group: STLS/SPLWG/ECWG experts and advisors
Proposed by: Tan Zi, David Peterson, Kelly Moran, Rebecca Sutton, Alicia Gilbreath, and Lester McKee (SFEI)
Time Sensitive: Yes, this is a project that can inform CEC monitoring design.

Proposed Deliverables and Timeline

Deliverable	Completion Season
Model data collation and preparation	Spring 2023
Model setup and pilot first order load estimation for one or more individual PFAS, such as PFOS or PFOA	Fall 2023
Draft technical report for peer review	Winter 2023
Final technical report and data sharing portal	Winter 2023

Background

Contaminants of emerging concern (CECs) – a diverse group of substances with different sources, chemical properties, and fate – wash into stormwater from a variety of emission sources. Previous CECs stormwater monitoring studies provide evidence that stormwater is a major pathway for many CECs to enter San Francisco Bay. The ongoing 'Integrated watershed modeling and monitoring implementation strategy' project (funded in 2021) is focusing on developing a general integrated modeling-monitoring framework that could be applied for individual CECs and providing a stepwise roadmap for future individual CECs modeling and monitoring from simple to complex. Understanding the quantity of CECs transported to the Bay via the stormwater pathway relative to other pathways is a high priority information need articulated by RMP stakeholders. Using a modeling tool to conduct a first order estimation of CEC stormwater load is therefore a near-term high priority to respond to the load comparison information need. Building upon the CECs watershed modeling roadmap being created by the complementary RMP projects listed above, we propose to conduct a modeling study to provide a screening-level estimate of specific CEC stormwater loads.

PFOS, PFOA, and other PFAS have been previously detected in San Francisco Bay biota, sediment, and water, including wastewater and stormwater pathways. Surface water monitoring conducted in 2009 found detectable levels of various PFAS, especially in areas impacted by wastewater and stormwater. PFAS were selected for this pilot project based on their status as a Moderate Concern CEC in the RMP tiered, risk-based framework for prioritizing CECs, high priority at the state level, and stakeholder interest from past projects. Some current and parallel projects, 'Stormwater Contaminants of Emerging Concern (CECs) Monitoring Strategy (Year 2)' and 'CECs in Stormwater: PFAS' will provide more PFAS monitoring data and develop a conceptual model for the PFAS sources and pathways, which are necessary information for the PFAS load estimation. This proposal is for 2023 funding to develop an approach for a pilot screening-level stormwater loading estimation for one or more individual PFAS, such as PFOS or PFOA.

Study Objectives and Applicable RMP Management Questions

This proposed study will be a pilot study for CECs stormwater load modeling and will provide information essential to understanding CECs loading from the stormwater pathway and provide answers to the ECWG and SPLWG high-level information needs. The overall project goal is to use PFAS as a pilot to design a modeling method for screening-level CECs stormwater load estimation to address the specific question: 'Relatively how large are PFAS loads in stormwater compared to the loads via other pathways?', as well as provide monitoring recommendations that meet the requirements for CECs load modeling. We expect to be able to use modeling to conduct an initial stormwater load estimation for one or more individual PFAS chemicals (e.g., PFOS and PFOA) and make suggestions about modeling setup for a full PFAS load estimate as well as other CECs stormwater loading. Following the philosophy of an integrated modeling-monitoring approach, this project will also benefit the CEC monitoring design by identifying priority data needs to support stormwater loads modeling. This proposed work will examine the different load modeling options suggested by the 'CEC stormwater load modeling exploration' project and select an appropriate method for estimating targeted individual PFAS such as PFOS or PFOA .

The specific goals of this study are: (1) to develop an approach for screening-level stormwater loading estimation for one or more individual PFAS, such as PFOS or PFOA, (2) to pilot a load estimation approach for modeling other prioritized stormwater CECs in the context of their specific physico-chemical properties, sources, transport pathways, and fate, (3) to identify data gaps and needs from a modeling perspective to inform the two ECWG proposed studies: 'Stormwater Contaminants of Emerging Concern (CECs) Monitoring Strategy (Year 2)' and 'CECs in Stormwater: PFAS', as well as the future monitoring designs for PFAS and other CECs. This load estimation study will help address both SPLWG and ECWG management questions.

Table 1. Study objectives and questions relevant to RMP SPL and EC workgroup management questions.

SPL Management Question	EC Management Question	Study Objective	Example Information Application
MQ1. What are the loads or concentrations of pollutants of concern from small tributaries to the Bay?	MQ2: What are the sources, pathways, and loadings leading to the presence of individual CECs or groups of CECs in the Bay?	Explore screening-level load modeling for CECs taking individual PFAS as a pilot; develop load estimation approach; identify data gaps.	Provide a pilot screening-level PFAS stormwater loading estimation for one or more individual PFAS chemicals (e.g., PFOS and PFOA)

Approach

The study will use the conceptual PFAS stormwater model developed by the 'CECs in Stormwater: PFAS' project and the list of the recommended load modeling methods suggested by the 'CEC stormwater load modeling exploration' project to select an appropriate method and customize it for the PFAS stormwater loading estimation.

As noted previously, CECs are a diverse group of substances with different sources and chemical properties. Not all CECs will be monitored or modeled the same way. The sources of CECs are product-oriented instead of land-use based. PFAS are representative of the complexity of CECs stormwater load modeling. PFAS is a group of thousands of chemicals with different characteristics (short chain, long chain, etc). PFAS can exist in different phases (dissolved, particulate) and can transform from precursors that are also members of the PFAS family. PFAS exists in a wide variety of products, which makes it challenging to track and identify source areas for stormwater loading. The PFAS conceptual model that will be developed in the 'CECs in stormwater, PFAS' project will inform the load model development by identifying outdoor PFAS uses, exploring correlations between these outdoor uses and watershed characteristics that can be used in modeling (e.g., land use or building age), examining the pathways by which PFAS reach urban runoff, and outlining key fate and transport characteristics. Atmospheric deposition should also be considered for the stormwater load estimation and comparison among PFAS transport pathways (air, stormwater, wastewater) to the Bay. We expect the challenges encountered in developing the PFAS stormwater load model can shed light on similar challenges to be expected in developing load models for other CECs in the future.

Currently available CEC stormwater samples, including PFAS samples, are not paired with flow monitoring, and cannot be used to validate the load estimation from the model directly. We will conduct a data analysis with the previous monitoring data and examine some simple relationships between landscape features (urbanization, directly connected impervious area, etc) and PFAS concentrations. Some of SFEI's previous modeling efforts, such as the simple load estimation model, RWSM (Lent et al., 2012, Wu et al., 2017) and the watershed dynamic model, WDM (Zi et al., 2021, 2022 [in review]) can be modified for the screening-level load estimation in this project. RWSM, as a simple tool to calculate the regional contaminant load, can be aided by the WDM hydrology and sediment simulation results from different hydrological response units (basic modeling unit of WDM) for the pilot load estimation for individual PFAS chemicals. Sensitivity analysis based on our modeling assumptions will be conducted to evaluate the uncertainties of the load estimation.

The study will yield recommendations for model modifications and monitoring data needed to support load estimates for stormwater for comparison to other pathways of PFAS.

The timeline, budget, and deliverables are provided in Table 2.

Table 2. Timeline and budget for major milestones of the modeling multi-year plan.

Budget ($k)	Tasks and Deliverable	Completion Date
25	PFAS stormwater load modeling method design based on the recommendations from the 'CEC stormwater load modeling exploration' project.	Apr-23
50	Monitoring and geospatial data analysis, verification of simple modeling interpretation, PFAS load modeling, modeling uncertainty analysis	Sep-23
15	Draft technical report	Oct-23
10	Final technical report	Dec-23

Budget

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

Table 3. Proposed budget.

Expenses	Estimated Hours	Estimated Cost (USD)
Project Staff (Modeling)	260	$30,000
Senior scientist and management review, ECWG and SPLWG review	90	$17,500
Project/Contract management	-	-

Data technical services	120	$15,000
GIS services	60	$7,500
Reporting	100	$15,000
Total	***680***	***$100,000***

Budget Justification

Labor Costs: Tasks will include synthesizing the literature; exploring numeric modeling approaches to estimate the CEC stormwater loads based on the conceptual model that will be developed by the 'CECs in Stormwater: PFAS' project ; examining modeling requirements and capabilities of different model options; and consulting with relevant experts and science advisors from both workgroups. Senior scientists and managers will help guide the process and review interim products.

Reporting Costs: RMP staff will produce a report to document model options and approaches, and provide recommendations of model platforms or model modification requirements for CECs stormwater loadings estimation.

Reporting

- Project progress presentations to SPLWG and ECWG (Spring, 2023)
- Draft model review report for peer review
- Final model review report

References

Lent, M.A., Gilbreath, A.N., and McKee, L.J., 2012. Development of regional suspended sediment and pollutant load estimates for San Francisco Bay Area tributaries using the regional watershed spreadsheet model (RWSM): Year 2 progress report. A technical report prepared for the RMP, SPLWG, STLS. Contribution No. 667. San Francisco Estuary Institute, Richmond, California. https://www.sfei.org/documents/development-regional-suspended-sediment-and-pollutant-load-estimates-san-francisco-bay

Wu, J., Gilbreath, A.N., McKee, L.J., 2017. Regional Watershed Spreadsheet Model (RWSM): Year 6 Progress Report. A technical report prepared for the RMP, SPLWG, STLS. Contribution No. 811. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/regional-watershed-spreadsheet-model-rwsm-year-6-final-report

Zi, T., McKee, L., Yee, D., Foley, M., 2021. San Francisco Bay Regional Watershed Modeling Progress Report, Phase 1. Report prepared for the Sources Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality. SFEI Contribution No.1038. San Francisco Estuary Institute, Richmond, CA.
https://www.sfei.org/documents/san-francisco-bay-regional-watershed-modeling-progress-report-phase-1

Zi, T., Braud, A., McKee, L., Yee, D., Foley, M., 2022. San Francisco Bay Regional Watershed Modeling Progress Report, Phase 2. Report prepared for the Sources Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality. SFEI Contribution No.xxxx. San Francisco Estuary Institute, Richmond, CA (in review).