REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

sfei.org/rmp

RMP Emerging Contaminants Workgroup Meeting

April 16-17, 2024

9:00 AM – 3:00 PM

Remote Access

https://us06web.zoom.us/j/87106175469

Meeting ID: 871 0617 5469

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DAY 1 AGENDA - April 16th

1.	**Introductions and Goals for This Meeting** The goals for this meeting: • Provide updates on recent and ongoing ECWG activities (today & tomorrow) • Discuss CEC Strategy Revision and future direction of the program (today) • Review Status and Trends monitoring data (today) • Overview of PFAS Sources to Solutions project (USEPA Water Quality Improvement Fund) and implications for RMP PFAS science (tomorrow) • Discuss ongoing stormwater CECs projects; joint meeting with the Sources, Pathways, and Loadings Workgroup (tomorrow) • Recommend which special study proposals should be funded in 2024 and provide advice to enhance those proposals (tomorrow) Meeting materials: Guidelines for Inclusive Conversations, page 8 2023 ECWG Meeting Summary, pages 9 - 33	9:00 Amy Kleckner
2.	**Information: RMP CECs Science Update** The ECWG science lead will present a brief update on current CECs activities. Desired Outcome: Informed Workgroup	9:15 Rebecca Sutton

3.	**Discussion: CEC Strategy Revision** The workgroup will review and discuss the draft CEC Strategy Revision document. Specific topics for discussion include: ● Classification of contaminants within the tiered risk-based framework, with a focus on High and Moderate Concern contaminants as well as additions and changes relative to prior years ● Toxicology strategy update, with focus on bioassays (as a preview for one of the special study proposals) ● Revised multi-year plan, with a focus on plans for future years Meeting materials: Draft CEC Strategy Revision document Desired Outcome: Feedback on the tiered risk-based framework and the multi-year plan	9:45 Rebecca Sutton, Ezra Miller
	Short Break	10:30
3.	**Discussion: CEC Strategy Revision (cont.)** See description above.	10:45 Rebecca Sutton
	Lunch	11:30
4.	**Information: Update on Nontarget Analysis of Bay Harbor Seals** The current presentation will provide preliminary results in the development of halogenated contaminant fingerprints in seal blubber collected from the San Francisco Bay area using a 2-dimensional gas chromatograph equipped with a high-resolution time-of-flight mass spectrometer (GC×GC-HR-ToF MS). Desired Outcome: Informed Workgroup	12:10 Sally Abskharoun (Clarkson)
5.	**Discussion: Proposed Study Design for Status and Trends Nontarget Analysis of Bay Water** A new addition to the S&T platform, nontarget analysis (NTA) will be performed at least every ten years to identify new CECs in Bay water. The workgroup will review a proposed study design that includes dry and wet season sample collection in summer 2025 and water year 2026, respectively. All samples would be analyzed using both liquid and gas chromatography-based NTA to assess both polar and nonpolar contaminants, tentatively identified via matching to spectral libraries. NTA data will be explored relative to characteristics including geography, seasonality, and available S&T target data. Meeting materials: Proposed Study Design Desired Outcome: Feedback on proposed study design	12:30 Rebecca Sutton, Tom Young (UC Davis)
6.	**Information: Update from the DTSC Safer Consumer Products Program** The Department of Toxic Substances Control's (DTSC) Safer Consumer Products (SCP) Program uses a precautionary approach to regulate chemicals in consumer products based on the potential for harm to people or the environment. The SCP Program represents one approach to reduce the release of CECs to California's aquatic environments. This talk will provide an overview of the novel approach that SCP takes to reduce the use of toxic chemicals in consumer products and the program's work on CECs to date. Desired Outcome: Informed Workgroup	1:00 Anne Cooper Doherty (DTSC)

	Short Break	1:30
7.	**Information: Update on the State Water Board CEC Strategy** The State Water Board established the Constituents of Emerging Concern (CEC) Program in 2021 to support California's Water Resilience Portfolio and actions that protect and restore water quality by driving pollution reduction from a range of sources. The CEC Program supports statewide source control programs for emerging contaminants that are hardest to treat, not regulated and/or routinely monitored, and have not been adequately tested for human or ecological toxicity. Primary objectives of this program include strategically prioritizing and characterizing CECs for monitoring and management to efficiently address their statewide emerging public health and water quality concerns. This talk will describe the draft CEC Program Strategic Plan, which was developed to guide the work of the CEC Program and describes the Water Board's approach to prioritize and manage CECs in California, and proactively ensure protection of drinking water supplies, public health, and the environment. Desired Outcome: Informed Workgroup	1:40 Erica Kalve (SWRCB)
8.	**Information: Update on PFAS in San Francisco Bay** The workgroup will review recent data on PFAS in Bay water and cormorant eggs developed through Status and Trends monitoring. In addition, preliminary findings from a special study applying the Total Oxidizable Precursors (TOP) assay on Bay water will be discussed. Desired Outcome: Informed Workgroup	2:10 Miguel Méndez
9.	**Information: Chlorinated Paraffins in Bay Sediment** The workgroup will hear an update on recent analysis of chlorinated paraffins in archived Bay sediment. This penalty-funded project employed a new analytical method offered by SGS AXYS to assess occurrence of short, medium, and long-chain chlorinated paraffins. These compounds are commonly used as additives in lubricants, plasticizers, flame retardants, and metalworking fluids and are considered persistent, bioaccumulative, and toxic. Desired Outcome: Informed Workgroup	2:40 Jennifer Dougherty
10.	**Information: Setting the Stage for Day 2** The workgroup will briefly review goals for tomorrow.	2:55 Rebecca Sutton
	Adjourn	3:00

DAY 2 AGENDA - April 17th

Including the Joint Meeting of Emerging Contaminants & Sources, Pathways, and Loadings Workgroups (10 AM to 12 PM)

Remote Access
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11.	**Summary of Yesterday and Goals for Today** The goals for today's meeting: ● Brief recap of yesterday's ECWG discussions and outcomes ● Overview of PFAS Sources to Solutions project (USEPA Water Quality Improvement Fund) and implications for RMP PFAS science ● MORNING: Discuss ongoing stormwater CECs projects; this is a joint meeting of ECWG & SPLWG ● AFTERNOON: Recommend which ECWG special study proposals should be funded in 2025 and provide advice to enhance those proposals; ECWG meeting	9:00 Amy Kleckner
12.	**Information: PFAS Sources to Solutions Project (USEPA Water Quality Improvement Fund)** The workgroup will receive an overview of a new USEPA-funded project, PFAS Sources to Solutions, a timely and innovative effort to address the urgent public health and environmental issue of PFAS in San Francisco Bay. Project partners include the RMP, local wastewater and stormwater agencies, academic scientists, and DTSC's Safer Consumer Products Program, among others. Over the 4-year project period, the project team will work with partners and stakeholders throughout the Bay Area to (1) monitor PFAS in the Bay and pathways and estimate PFAS loads to the Bay from municipal wastewater and urban stormwater runoff; (2) develop high-quality information on PFAS-containing products to inform regulatory action to support the reduction of urban PFAS sources; and (3) communicate widely with both experts and non-experts on PFAS sources, how to reduce PFAS pollution, and key information gaps to guide future efforts to identify and address urban PFAS sources. The RMP's PFAS Synthesis and Strategy special study, launching this year, will feed directly into the work for this new project. Desired Outcome: Informed Workgroup	9:15 Kelly Moran, Ezra Miller, Diana Lin
	Short Break	9:45

13.	**Introductions and Goals for the Joint Meeting** The goals for this meeting: ● Provide updates on recent and ongoing stormwater CECs monitoring & modeling activities ● Discuss straw proposal for stormwater CECs monitoring design Meeting materials: Guidelines for Inclusive Conversations, page 8 2023 ECWG Meeting Summary, pages 9-33	10:00 Amy Kleckner
14.	**Information: Stormwater CECs Projects Update** This agenda item will cover: ● Overview of the process to develop the RMP Stormwater CECs integrated modeling and monitoring approach and the projects feeding into its development (10 minutes) ● SFEI Mayfly remote stormwater sampler pilot season, design improvements, and other sampler options (20 minutes) ● Modeling CECs stormwater loads - literature review & recommendations (10 minutes) ● Updates & key insights from other projects (5 minutes) ● Q&A and discussion Meeting materials: RMP Stormwater CECs Update; see also background and approach sections of Stormwater CECs ‘25 proposal Desired Outcome: Informed Workgroup	10:10 Kelly Moran, Kayli Paterson, Don Yee, Pedro Avellaneda
15.	**Discussion: Stormwater CECs Integrated Modeling & Monitoring Approach: Straw proposal for stormwater CECs monitoring design** This agenda item will cover: ● Key background informing straw proposal development ● Straw proposal for monitoring design ● Workgroup discussion Desired Outcome: Feedback on straw proposal monitoring design	11:10 Kelly Moran
16.	**Next steps** This agenda item will cover: ● Upcoming schedule	11:55 Kelly Moran
	Lunch	12:00

17.	**Summary of Proposed ECWG Special Studies for 2025** The ECWG science lead 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. 2025 RMP ECWG Special Study Proposals include: ● Stormwater CECs Monitoring & Modeling 2025 - $300,000; *p.35-48* ● Plastic Additives in Bay Water and Archived Sediment - Two options, $172,940,$235,200; *p.49-58* ● Quaternary Ammonium Compounds (QACs) in Bay Water and Stormwater -Two options, $106,000, $164,000; *p.59-65* ● Synthetic Dyes in Bay Sediment, Water, Wastewater, and Urban Stormwater Runoff - $170,600; *p.66-73* ● NTA of Bay Fish (year 2) - $76,000; *p.74-82* ● Nontarget and Target Analysis of Fibers and Urban Stormwater - $136,000; *p. 83-99* ● Stormwater In Vitro Toxicity Screening - $26,000; *p.100-107* Tier Two Proposals describe projects that could be funded if additional resources become available *(p.108-112)*: ● Stormwater CECs Monitoring & Modeling 2025 (additional priorities) - $150,000 ● PFAS NMR Analysis in Wastewater, Stormwater, and Bay Matrices - $385,000 ● Tire Wear Emissions and Washoff Estimates Journal Paper - $15,000 ● Tire Rubber Marker Analysis - $105,000 ● PFAS Analysis Add-on to Stormwater Depth Monitoring Pilot - $55,000 ● Analysis of PFAS Wet Deposition Pathway - $251,000 - $440,000 Special Study Proposals for other workgroups that are relevant to ECWG include: ● Fixed station watershed monitoring network (multiple workgroups) Meeting materials: 2025 Special Study Proposals, pages 34 - 112	12:30 Rebecca Sutton, Alicia Gilbreath, Diana Lin, Don Yee, Ezra Miller, Kayli Paterson, Kelly Moran, Miguel Méndez, Pedro Avellaneda
18.	**Discussion of Recommended Studies for 2025 - 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.	1:15 Amy Kleckner
19.	**Closed Session - Decision: Recommendations for 2025 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 ECWG 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 ECWG to the TRC regarding which special studies should be funded in 2025 and their order of priority.	2:10 Eric Dunlavey

20.	**Report Out on Recommendations**	2:50 Eric Dunlavey
	Adjourn	3:00

Bay RMP Stakeholder and Workgroup Meetings

Guidelines for Inclusive Conversations

This document is intended as a guideline for engagement at Bay RMP Technical Review Committee, Steering Committee, and Workgroup meetings. This is a living document. If you have input on what could be added, please email Amy Kleckner (amyk@sfei.org).

Zoom Etiquette

- Rename yourself - consider adding your name, organization, preferred pronouns and whose native land you are on.
- "Raise your hand" virtually if you wish to speak.
- In the case of a land acknowledgement, take the time to determine whose native land you are on at the time of your meeting (https://native-land.ca/). People may be invited to share the name in the chat.

Meeting Agreements[1]

- TRY IT ON: Be willing to "try on" new ideas, or ways of doing things that might not be what you prefer or are familiar with.
- PRACTICE SELF FOCUS: Attend to and speak about your own experiences and responses. Do not speak for a whole group or express assumptions about the experience of others. Work on examining your default assumptions about another person's identity or lived experience.
- UNDERSTAND THE DIFFERENCE BETWEEN INTENT AND IMPACT: Try to understand and acknowledge impact. Denying the impact of something said by focusing on intent is often more destructive than the initial interaction.
- PRACTICE "BOTH / AND": When speaking, substitute "and" for "but." When used to connect two phrases in a sentence, the word "but" essentially dismisses the first phrase altogether. Using "and" acknowledges multiple realities and promotes inclusion.
- REFRAIN FROM BLAMING OR SHAMING SELF & OTHERS: Practice giving skillful feedback.
- MOVE UP / MOVE BACK: Encourage full participation by all present. Take note of who is speaking and who is not. If you tend to speak often, consider "moving back" and vice versa.
- PRACTICE MINDFUL LISTENING: Try to avoid planning what you'll say as you listen to others. Be willing to be surprised, to learn something new. Listen with your whole self.
- RIGHT TO PASS: You can say "I pass" if you don't wish to speak.
- AVOID JARGON: Try to avoid using jargon and/or acronyms.
- IT'S OK TO DISAGREE: Not everyone will be in agreement all of the time, and that's ok!

[1] Adapted from Visions, Inc. Guidelines for Productive Work Sessions found at: https://www.emergingsf.org/wp-content/uploads/2017/08/EBMC_AgreemntsMulticulturalInteractions15.09.13-copy.pdf.

FINAL

RMP Emerging Contaminants Workgroup Meeting

April 19, 2023
San Francisco Estuary Institute

Meeting Summary

ECWG Science Advisors	Affiliation	Present
Bill Arnold	University of Minnesota	Yes
Miriam Diamond	University of Toronto	Yes
Lee Ferguson	Duke University	Yes
Derek Muir	Environment and Climate Change Canada	Yes
Heather Stapleton	Duke University	Yes
Dan Villeneuve	U.S. Environmental Protection Agency	Yes

Attendees

Adam Wong (SFEI)
Alicia Chakrabarti (EBMUD)
Alicia Gilbreath (SFEI)
Amy Kleckner (SFEI)
Andria Ventura (Clean Water Action)
Anna Mahony (U. of Minn.)
Anne Cooper Doherty (DTSC)
Autumn Ross (SFPUC)
Ben Priest (CIL)
Bernard Crimmins (Clarkson University)
Blake Brown (CCCSD)
Bonnie de Berry (EOA)
Bushra Khan (UC Davis MPSL)
David Robertson (City of San Jose)
Diana Lin (SFEI)
Don Yee (SFEI)
Elana Varner (DPR)
Eric Dunlavey (City of San Jose)
Erica Kalve (SWRCB)
Ezra Miller (SFEI)
Gaurav Mittal (SFBRWQCB)
Jay Davis (SFEI)
Jaylyn Babitch (City of San Jose)
Jennifer Doughtery (SFEI)
Jennifer Teerlink (DPR)
Julie Weiss (City of Palo Alto)
June-Soo Park (DTSC)
Kaitlyn Kalua (OPC)
Kayli Peterson (U of Charleston)
Karin North (PA)
Kelly Moran (SFEI)
Lester McKee (SFEI)
Louia Harding (WDFW)
Luisa Valiela (US EPA Region 9)
Mala Mattanayek (Integral Consulting)
Manoela de Orte (SWRCB)
Mary Lou Esparza (CCCSD)
Martin Trinh (SFEI)
Mary Cousins (BACWA)
Maureen Dunn (Chevron)
Maya McInerney (SFBRWQCB)
Meltem Musa (OEHHA)

Million Woudneh (SGS AXYS)
Miguel Mendez (SFEI)
OIMA staff (SWRCB)
Pedro Avellaneda (SFEI)
Rebecca Sutton (SFEI)
Reid Bogert (C/CAG)
Richard Grace (SGS AXYS)
Robert Budd (CDPR)
Ruth Sofield (Western Washington Univ.)
Shoba Iyer (SF Environment)
Simona Balan (DTSC)
Simret Yigzaw (City of San Jose)
Tan Zi (SFEI)
Terry Grim (independent)
Tom Mumley (SFBRWQCB)
Tom Bruton (DTSC)
Tom Hall (EOA Inc.)
Violet Renick (Orange County Sanitation)
Xueyuan (Helen) Yu (Central Valley RWQCB)
Xin Xu (EBMUD)

DAY ONE - April 19, 2023

1. Introductions and Goals for This Meeting

Amy Kleckner began by highlighting remote meeting tips, reviewing the Zoom platform functionalities, and giving a land acknowledgment to the Native peoples of the San Francisco Bay Area. She also presented the group with guidelines for inclusive conversations. Amy then introduced the workgroup advisors and continued with a brief roll call for the various groups present to introduce themselves.

Amy continued by reviewing the ECWG two-day agenda, including tomorrow's joint meeting with SPLWG, and giving an overview of the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), including the program's goals, history, management questions, monitoring structure, and budget. Additionally, Amy communicated the goals of the meeting, highlighting discussion on the science during updates on current projects, prioritization of special study proposals, and future directions.

2. Discussion: CECs Science Update

Rebecca Sutton started the workgroup meeting with a brief update of current CECs efforts and an overview of the RMP workgroup structure. She reintroduced the CECs team, including the newest addition, Jennifer Dougherty, as an Environmental Scientist. Rebecca's outline of current CECs activities categorized efforts into four strategic elements: (1) Bay monitoring and risk evaluation, (2) pathways monitoring and modeling, (3) novel approaches, and (4) learning from others/sharing expertise. Related ongoing projects and activities were noted for each element, respectively.

Rebecca started by presenting the updated tiered risk-based framework, with an additional Very High Concern tier, and updated placements of contaminant classes. Tom Mumley asked about the asterisks on some classes, which Rebecca noted are there to indicate classes with ongoing studies that may change their classification under the new framework. Rebecca then highlighted current Bay monitoring projects, beginning with contaminants in the high concern tier including RMP Status and Trends (S&T) monitoring of organophosate esters (OPEs) and per- and polyfluoroalkyl substances (PFAS) in water, with further analysis of sediment, marine mammals and prey fish for PFAS. She continued with Moderate Concern CECs including studies of bisphenols in water and sediment through S&T as well as special studies of alkylphenol ethoxylates & other surfactants in water and sediment. Within the possible concern tier, there are two ongoing special studies examining quaternary ammonium compounds (QACs) and tire chemicals (not yet formally classified), while a SEP-funded study is monitoring chlorinated paraffins in sediment. Rebecca also spotlighted pathways monitoring work such as multi-year data available for stormwater for various class (PFAS, OPEs, bisphenols, tire chemicals, and ethoxylated surfactants), with preliminary data to be presented later in the meeting. In addition, Rebecca noted the various wastewater monitoring projects including study of PFAS in collaboration with Bay Area Clean Water Agencies (BACWA) and QACs, both of which will also be discussed in presentations on Day 1. Further, she mentioned the pending data on ethoxylated surfactants as well as two recently completed reports on select organic sunscreens (with a pending manuscript) and bisphenols.

Rebecca continued with discussion of novel approaches ongoing across various projects, focused on non-targeted analysis (NTA) and ecotoxicology. There have been previous presentations on sediment NTA with a manuscript in preparation for a study of nonpolar compounds using GC-based methods. In addition, a manuscript and fact sheet are planned for an examination of polar compounds in sediment using LC-based methods. Rebecca also noted an ongoing NTA project of marine mammals using both GC and LC-based methods. Further, a special study mining past results is set to begin later this year. She highlighted a possible future ecotoxicology project using "new approach methodologies," in particular an in-vitro cell assay that advisor Dan Villeneuve is tracking that has potential stormwater applications to better understand toxicity. She discussed a couple of recently published and forthcoming scientific publications, such as a QACs review paper organized by the Green Science Policy Institute and a review paper on tires as a complex pollutant. Miriam Diamond noted the need for a specific website with all SFEI publications, provided here: https://www.sfei.org/biblio. Rebecca noted upcoming conferences (SETAC in Dublin, Ireland; SETAC in Louisville, Kentucky; and ACS in SF) to be attended by the CECs group to share findings and learn about global efforts relevant to the RMP. Rebecca ended with a short overview of the current RMP structure, indicating the variety of workgroups and collaborative efforts with ECWG.

3. Discussion: CECs Strategy Revision

Rebecca Sutton continued the day with a discussion on the draft CEC strategy revision. She briefly reviewed the current draft, highlighting four significant components in the revision: tiered risk-based framework, monitoring and management recommendations, risk quotient calculations (including approaches to non-detects), and secondary factors. She then noted the timeline for the revision, with a full draft report and meeting with the ECWG Strategy Subgroup in the fall, draft report for the ECWG in December, and final draft in Spring 2024.

Rebecca continued with an overview of the important topics of discussion in this item, beginning with revisions to the ECWG management questions (MQs). Based on previous guidance, the fourth management question, focused on understanding changes in CECs concentrations in the Bay, would now include pathways and potential drivers of the trend. She noted that the Subgroup generally agreed with the revision, though indicated a potential need for clarification of the difference in Bay processes (MQ 3) and anthropogenic drivers. Rebecca stated the accompanying text will include further explanation to note these drivers as anthropogenic actions. She opened the floor to discussion, with Miriam Diamond noting the potential overlap in MQs 2 and 3, with Rebecca Sutton noting the second is a focus on pathways while the third is in the Bay. Miriam recommended further clarification within the adjacent text and review of the responses to the MQs to limit redundancy, while also noting a potential nexus in MQs 4 and 5 that combines retrospective and future/predictive work, including an integrated monitoring/modeling approach. Lee Ferguson agreed with the current separation of MQs 2 and 3, and notes the combination of questions is dependent on their use across studies. Rebecca remarked that the studies aim to answer as many management questions as possible within the scope and that processes could be added to the second question for further clarity. Discussion continued on whether to group or split the questions, with several members spotlighting the purpose and use of the questions to guide potential changes. Miriam noted a more thorough response in each special study proposal to answering some of these questions would be helpful. Others discussed the differences in physical processes and anthropogenic drivers, highlighting the important integration of climate change related drivers. Rebecca wrapped up the discussion, noting the limited time and further communication via email.

Rebecca followed with other updates in this draft including the elevation of pathways science as its own element within the strategy, including an updated table laying out the potential priorities for pathways projects. The table highlights each chemical class under the tiered risk-based framework, its chemical properties, notable sources, and current knowledge of potential pathways to the Bay. Initial feedback from the Subgroup was positive with continued discussion remaining for the role of the RMP in evaluating sources. The Subgroup also noted care in specific terminology used to describe available knowledge or understanding of occurrence in pathways, and whether in-water applications (such as boats, docks, etc.,) should be included within the table. Lee Ferguson noted interest in the impacts of boats and related waters to the Bay while also recommending changes to specify the terminology describing the importance of individual pathways to the Bay. Tom Mumley recommended consideration of each pathway with notes of current RMP knowledge and data gaps, instead of the relevant significance, though this could be added as footnotes over time. He also suggested consideration of back-of-the-envelope calculations for the relative loads of these pathways to the Bay to better understand their influence. Several meeting attendees agreed with both suggestions. Kelly Moran asks if industrial wastewater should be specifically separated from municipal wastewater, which Tom noted would likely work better as two different categories.

Ezra Miller then presented an update to the RMP ecotoxicology and human health approach, highlighting a recent draft living document of all of the relevant thresholds used for contaminants with available data in the RMP. Ezra began with an introduction to ecotoxicology thresholds, noting the thresholds included within the spreadsheet are ecosystem-level thresholds calculated from toxicity data across species and endpoints (as opposed to single species thresholds such as LC50s). The draft thresholds spreadsheet indicates the variability in available thresholds for each chemical, with filtering of column O (to “Y”) showing recommended thresholds for use in the tiered risk-based framework. These thresholds are recommended based on expert judgement, prioritizing thresholds that were calculated using more experimental data and chronic/sublethal exposures, lower (i.e., more protective values, and California-specific values.

For a few prioritized compounds with no existing ecosystem-level thresholds, Ezra can calculate a new threshold, such as for 6PPD-quinone, using available ecotoxicology data. Ze suggested strategic use of a read-across approach to use an available contaminant threshold for structurally similar compounds, usually within the same class. Ze also noted there are some cases where no thresholds are available due to limited data. An additional secondary factor of consideration is the potential for cumulative impacts of contaminants, with an updated approach to understand additive impacts. Key human health thresholds for fish consumption are available in the spreadsheet, with preference given to California values; Ezra does not propose to calculate human health thresholds when these are unavailable. Initial feedback on the approach recommended further consideration of the scope of each contaminant class. Heather Stapleton asked about updating the spreadsheet considering the complexity of mixtures and current use of CAS numbers, with several participants echoing connection to mixtures and polymers. Ezra noted this is an ongoing challenge and the team would continue to tackle potential solutions.

Rebecca Sutton continued with discussion on updates to the tiered risk-based framework. The ecotoxicity thresholds, from the spreadsheet, are compared to the 90th percentile occurrence level to develop a risk quotient (RQ). This value serves as a starting point for classification within the risk-based approach, along with secondary factors such as persistence, temporal trends, and cumulative impacts. In development of the RQ, more recent data (since 2013) will be prioritized, with at least 10 samples needed. Further, this is a class-based approach, with chemical classes requiring an approach where the individual contaminant of highest concern driving the risk tier for the class, while other groupings may warrant separation of subclasses within different tiers. Rebecca then briefly reviewed the updated risk tiers, highlighting the addition of a Very High Concern tier and the various RQ thresholds across tiers. Several participants noted concerns with current communication of the range of RQs associated with each tier, with Tom Mumley recommending potential further clarification via symbols to help note the specific thresholds and secondary factors. Rebecca noted further text could be used to specifically describe the risk evaluation for each class. She also briefly noted a potential update to the illustration of the Possible Concern tier, suggesting a figure that better demonstrates the uncertainty and broader relative risk of this category. Tom remarked that this design could lead to misinterpretation of the Possible Concern tier, with clarification needed on what is presented. Rebecca noted the strategy will discuss a list of new/unmonitored contaminants to be on-ramped, and Possible Concern contaminants to be off-ramped, and can further emphasize this aspect in the figure through a caption.

Rebecca then reviewed the monitoring and management recommendation summary table, soliciting any feedback from meeting participants. Lee Ferguson asked about tracking product use and market trends within the Low Concern class, and the process to reconsider contaminants based on new information. Miriam Diamond agreed a process to update based on new information would be useful. Tom Mumley noted specific needs would warrant tracking specific classes, as it is not feasible to track everything.

Rebecca then gave a quick overview of an updated approach to analysis of non-detects (ND). Each class would be analyzed to select an appropriate ND substitution approach, which would also be informed by information on use, environmental distribution, and analytical methods. The replacement of NDs with half the method detection limit (MDL) is the preferred option that has been shown to perform adequately compared to other ND treatment methods. This would be limited by the detection frequency (potentially above 50%) of contaminants. In addition, this includes a sensitivity analysis when the ND substitution may influence the conclusion, with comparison to other substitutions including 0 and MDL, as well as comparison to other available data. Several meeting participants noted careful consideration in this approach with clear understanding of its use and limitations (such as sample size and distribution of normality). Don Yee noted a range from 0 to MDL could also work to represent the potential concentration in a matrix. Rebecca agreed that this could be a useful tool, though for communication it would be most useful to have a single value. Tom Mumley notes the specific use of the data may warrant different approaches.

Rebecca continued by presenting an example CEC profile of organophosphate esters (OPEs). These profiles would serve as a concise communication of essential data and information within the CEC strategy revision, with standardized content and organization. This also would serve to demonstrate the rationale for threshold selection, risk evaluation, and future monitoring strategies. The profile structure includes an overview of the contaminant class (i.e., definition, properties, use), RMP monitoring to-date with risk evaluations, current and upcoming management actions, and future monitoring strategy. She continued by spotlighting these sections for OPEs, asking for feedback on the current format. Heather Stapleton noted the need for complete inclusion of the OPEs class in the text, with potential separation of chlorinated and non-chlorinated contaminants, in current toxicity thresholds. Several meeting participants noted further description of the consideration of the class-based approach in each class, including definition and relevant secondary factors, and brief summary of the narrative in the full report. Tom Mumley indicated the need to specify the recommended scope and scale of Status and Trends monitoring for relevant classes.

She continued with a brief overview of the multi-year plan and future directions. She introduced the updated stormwater monitoring and modeling approach which will be further discussed during the joint meeting on the second day. She then discussed any ideas or recommendations for monitoring in future years for the various contaminant classes of interest, NTA, and toxicology. She highlighted the potential use of a new in vitro assay for stormwater monitoring (in development with Dan Villenueve). Lee Ferguson expresses interest in point-source industrial discharges with Anne Cooper Doherty also noting interest in in-water pathways.

4. Information: Update on PFAS Sewershed Source Investigations

Diana Lin presented the preliminary results of a SF Bay regional study of wastewater to investigate the fate and transport of PFAS, fluorine rich and persistent compounds with known negative effects. She notes this project is a collaboration with BACWA, the SF Regional Water Quality Board (RWB), and the State Water Board, which has provided an opportunity to efficiently monitor PFAS across the region. As the second phase of a two-phase study, POTW participants collected sewershed samples (before the waste streams enters the POTW influent) from diverse residential communities and various industries to understand potential sources to wastewater. All samples in both phases of the study were examined using EPA method 1633 with 40 target analytes and most (except effluent in Phase 1) were also analyzed using the total oxidizable precursors (TOP) assay, which converts oxdizable PFAS precursors to detectable PFAS end-products to better understand the presence of PFAS in wastewater samples.

Diana continued by first summarizing the results from Phase 1 of the study as important context to understand the Phase 2 study design and preliminary results. Phase 1 of the project examined wastewater influent, effluent, and biosolids (digested sludge) from 12 representative municipal POTWs. Analysis at these municipal POTWs yielded comparable concentrations for the sum of PFAS, with median concentrations of 27 ng/L in influent, 58 ng/L in effluent, and 178 ng/g in biosolids. The precursors in influent can be converted to PFAS end-products during wastewater treatment, which explains the higher levels of target PFAS observed in effluent relative to influent. In addition, the biosolids showed a different signature of PFAS compared to influent and effluent, particularly an intermediate precursor 5:3 FTCA, which could indicate the breakdown of precursors throughout the digestion process. The TOP method PFAS concentrations were significantly higher across matrices studied, with median concentrations of 231 ng/L in influent and 594 ng/g in biosolids. Overall, there is a significant presence of unknown PFAS precursors in both influent and biosolids, demonstrating the importance of continued analyses using broad methods of analysis, and further understanding of potential sources upstream of the facilities themselves.

Diana then reviewed the recent Phase 2 results, where influent, effluent and biosolids samples were collected from 7 municipal POTWs, as well as influent from several residential and industrial flows within their respective sewersheds, to understand their contribution to PFAS levels in wastewater. Results presented today are preliminary, and results may change depending on a more careful review of the data. Only the target results presented today have undergone a QA review, and TOP have not been undergone QA review, although preliminary data will be presented. The QA officer's evaluation of the Target dataset was that the dataset was acceptable, with 5% of data flagged for quantification issues; there were many estimated values where the detected value lies between the method detection limit (MDL) and reporting limit (RL). Field and equipment rinse blanks were mostly below detection limits except for 6:2 FTS in a few field blanks. Compared to Phase 1, the median value of the sum of PFAS in influent was nearly double, which could be due to lower detection limits for PFOS, as it was more widely detected, along with contributions from the many analytes observed at levels close to MDLs. Influent TOP data showed a similar median level of precursors compared to Phase 1, indicating their continued significant presence in wastewater. Effluent target results were slightly lower than Phase 1, with TOP results showing levels higher than target results but well below those in influent TOP, which could indicate partitioning to biosolids. Similar to Phase 1, biosolids in Phase 2 showed a different signature relative to influent and effluent, with high levels of precursors present, including 5:3 FTCA.

In addition, Diana discussed the diverse residential neighborhoods sampled, highlighting the wide variety and range of measured concentrations across neighborhoods. Most sampled residential areas were below median influent concentrations, though a few showed elevated levels. When examining TOP results, more residential samples exhibited levels above POTW influent. For industrial samples, industrial laundries were presented as they provided some of the most interesting results relative to other sampled industries. The levels measured in industrial laundries varied significantly, with several facilities indicating elevated PFAS concentrations especially with the TOP assay. She concluded with upcoming steps including completion of the QA/QC review, ongoing data analysis, upload of POTW target data to Geotracker, and a final report early next year.

Meeting participants discussed the various preliminary results, with Lee Ferguson noting the potential for underestimation in TOP due to incomplete conversion of precursors. Diana noted the use of matrix spikes within TOP samples and analysis by the lab to ensure complete oxidation. Lee also noted interest in understanding the PFAS signature in the laundry samples and expressed confidence in high values of a few laundry samples, based on his experience measuring high levels of PFAS in textile wastewater. Luisa Valiela and Maggie Monahan questioned if the sewershed samples were truly representative of all Bay Area sewersheds due to their variability. Diana clarified that the sewershed investigations were designed to be a screening study that may inform follow-up investigations and was not designed to be representative of the sampled industries. Heather Stapleton commented that inclusion of GC-MS methods would be useful to understand vaporization of PFAS. Erica Kalve asked about AOF analysis results, with Richard Grace noting that these analyses are more experimental and to exercise caution with interpretation. Simona Balan asked about sewershed data from semiconductor facilities, and Diana Lin noted that results were not more than an order of magnitude above median influent values. Tom noted the complicated factors in analysis of the data and indicated further interest in understanding the full context of fate and transport of PFAS in the Bay.

5. Information: Update on PFAS in Bay Fish

Miguel Mendez presented on a recent special study examining PFAS in archived fish samples across SF Bay. The RMP has monitored sportfish since 1994, and most recently in 2019, including hundreds of samples of various fish species and a variety of contaminants analyzed over several sampling rounds (every three years until 2009, then every five years). This RMP data is a prime example of actionable information for the public, especially as it has helped inform the Bay Consumption Advisories developed by the Office of Environmental Health Hazard Assessment (OEHHA). Jay Davis spotlighted rare release of a Bay advisory update this day based on mercury and polychlorinated biphenyls (PCBs) concentration of fish caught in the Bay. The RMP has monitored fish for PFAS since 2009, detecting a variety of PFAS across 83 samples from up to 8 fish species. A decade of monitoring data has found PFAS persisting at concentrations exceeding thresholds established by some US states for the development of consumption advisories, though, no human health thresholds have yet been established for PFAS in California fish.

Miguel discussed the current study aims to better understand the temporal and spatial trends of PFAS in Bay fish through the analysis of an additional 56 archived composite samples from four fish species collected across 10 Bay locations in three sampling rounds in 2009, 2014, and

2019. Fish species were selected based on a number of criteria, including species that are: popular for consumption, sensitive indicators of problems (accumulating relatively high concentrations of contaminants), widely distributed, representative of different exposure pathways (benthic versus pelagic), and included in past monitoring. An additional special study on PFAS in prey fish was done in 2012, in locations not typically sampled that are near marine mammal feeding sites; these data were included to compare to relevant species eaten recreationally in the Bay (shiner surfperch). The archived samples were analyzed for 40 PFAS using EPA method 1633, with the lowest detection limits and most analytes examined so far.

Miguel continued by noting the method of analysis for combining data from previous sampling rounds, with less sensitive detection limits, to the most recent dataset of archived samples in 2022. This includes both older and newer data together within one dataset with further comparison via non-detect substitution methods to accommodate for the variety of detection limits over the past decade. Currently, the RMP method for non-detect treatment is to replace these values with 0. An updated methodology provides a nuanced approach with any analytes detected above 60% in the newest sampling round meriting further examination of concentrations and MDLs to determine the most appropriate substitution of 0, 0.5MDL, or MDL. The presentation focused on the normal RMP method with inclusion of the new substitution method as a comparison. Overall, median and average concentrations remained similar even with substitution changes.

Up to 17 PFAS have been detected in archived Bay fish since 2009, with PFOS and PFOSA, a precursor, the two most frequently detected analytes. Long-chain perfluorocarboxylates (PFCAs) made up most of the remaining PFAS signature. For shiner surfperch, the sum concentrations of PFAS appear to be leveling off near 5 ng/g ww (median), with a comparison of PFAS across subembayments indicating levels consistently higher in the South and Lower South Bays. However, the highest sum concentration of PFAS in shiner surfperch was found in the Carquinez Strait. This is of particular interest to understand the impact on recreational fishers in the area, which will be further elucidated through an EPA funded study by All Positive Possible, a local environmental justice organization, with SFEI collaboration. The sum concentration of PFAS in striped bass are above 5 ng/g since 2009 with the highest in 2019 (median 14 ng/g) likely due to the collection of samples from only Lower South Bay, also shown to have higher concentrations. All samples showed PFOS levels close to or above a current New Jersey general population threshold of 3.9 ng/g ww for a single serving per week. White croaker concentrations were more variable across years (range: ND – 29 ng/g ww), with 2014 samples showing higher levels overall, which may be due to these being analyzed as whole body compared to typical skin-off fillet. This work will be highlighted in a presentation at SETAC Europe and upcoming draft report and manuscript. Miguel concluded by noting future directions including monitoring of prey fish this summer, sportfish in 2024, and monitoring of fish in Carquinez Strait with All Positives Possible.

Several meeting participants discussed the use of non-detect substitution methods and noting caution when applying them across several analytes. Heather Stapleton mentioned particular care in performing statistical analyses and noting the changes that may occur when data are substituted. Robert Budd noted the difficulties of analyzing censored data, with Derek Muir highlighting potential benefits to better understanding the true concentrations of contaminants relative to their detection limits. Derek also noted the unique result of 5:3 FTCA in fish and further investigation into the presence of PFBA as it is likely a terminal product.

6. Information: Quaternary Ammonium Compounds (QACs) Update

Anna Mahony, a graduate student with Dr. Bill Arnold of the University of Minnesota, presented the preliminary findings of the QACs in wastewater and the environment study, with preliminary findings on wastewater influent, effluent, and biosolids from Bay Area treatment plants as well as Bay Area stormwater and surface water. QACs are a broad category of compounds separated into several subclasses: benzalkyldimethyl ammonium compounds (BACs), dialkyldimethyl ammonium compounds (DADMACs), ethylbenzylalkyl ammonium compounds (EtBACs), and alkyltrimethyl ammonium compounds (ATMACs). These compounds have been used since the 1930s in a wide range of industrial, agricultural, and consumer products, especially as antimicrobials. The emergence of the COVID-19 pandemic has increased the use of QACs, known to be toxic to aquatic species and contribute to the development of antibiotic resistance in bacteria. Anna briefly reviewed the extraction methods, noting that the compounds stick to filter materials, requiring additional extraction steps to accurately discern concentrations in samples.

Anna continued by briefly discussing a few stormwater and Bay water sites as well as the three different wastewater facilities analyzed (anonymized as Plants X, Y, and Z) to understand the most common QACs present and understand the temporal trends of QACs in wastewater throughout the pandemic. She discussed preliminary stormwater results, which showed sum of QACs in a range from about 800 ng/L to 1800 ng/L. BACs and DADMACs were dominant in these samples. Preliminary surface water results indicated variability across sites, with most around the 100 ng/L range and a few above 600 ng/L. She continued with discussion of preliminary wastewater results: in Plant X, QACs levels are variable throughout a three-year period in influent, though most effluent samples are below 2 ug/L. Limited biosolids samples (range: 150-325 ug/L) appear to show an increasing trend over time, with C8 and C10 DADMACs as the most prevalent. Plant Y showed more consistent concentrations of QACs over time, with influent around 35 ug/L and effluent concentrations below 0.7 ug/L. QACs concentrations appear to vary for each sampled lagoon bed, though the most recent biosolids show the highest sum of QACs (which includes the first year of the pandemic; range: 100-200 ug/L). Plant Z showed some variability across all matrices, with some increase in EtBACs in influent over time. Influent sum QACs concentrations ranged from 20-100 ug/L, effluent ranged from 0.5-2.5 ug/L, and biosolids from 200-1200 ug/L.

Anna then highlighted the difference in QACs fingerprint in influent, which exhibited similar QACs profile as those used in disinfectants, while effluent and biosolids are clearly different. This could indicate degradation happening in the treatment process. Across facilities, there is a 97% average removal of QACs from influent to effluent, though some could still be released into the environment. Several participants discussed the study and its findings. Tom Mumley noted a correction of flow for one of the facilities. Anne Cooper Doherty noted DTSC is currently undertaking a systematic investigation to understand where QACs are being used.

7. Information: In-Bay Fate Modeling

In the interest of time, Jay Davis opted to forgo a presentation and instead send a short email to the workgroup detailing the progress on a multi-year workplan for modeling legacy contaminants (PCBs), CECs, and sediment in the Bay. A robust in-Bay fate model will be valuable in guiding S&T monitoring of CECs (e.g., placement of sampling stations and timing of sample collection) and in assessing the likely spatial distribution and temporal duration of potential water quality impacts.

8. Discussion: Integrated Watershed Bay Modeling Strategy and Pilot Study

Tan then introduced the general integrated modeling framework and strategy, highlighting any feedback on contaminant classes of high priority and specific management questions to tackle first. He began the discussion noting a key step, scenario building, where the specific needs of the model can first be identified, including model structure, data needs, scenario representations, and building of a model implementation plan. This then leads into a core modeling framework with various modules to tackle specific questions. These modules are customizable and can range from simple to complex. Management questions are then used as a guide to develop a specific question and a clear goal (output) for the model.

Tan then provided two examples of this modeling framework in action with the first highlighting a potential project to estimate a screening level stormwater load for CEC X. He reviewed the steps to consider in scenario building, such as land features, solubility, and rainfall. He noted a sample core modeling framework and the important modules to consider (i.e., urban runoff and watershed loads). He then highlighted a more complex example assessing the relative contribution of different pathways to the Bay. This would require additional scenario representations to consider stormwater and wastewater loads separately, and involving additional modules from the core modeling framework. The overall general modeling strategy is intended to be flexible and iterative to best fit the goals and needs of a specific project. Tan concluded by noting a complete modeling strategy will be done in early fall and asking for feedback on CECs and management questions of highest interest.

Meeting participants discussed the new directions of the modeling project, with Miriam Diamond indicating appreciation for the flexibility and comprehensiveness of the strategy. Derek Muir and Miriam Diamond initially suggested PBDEs as a contaminant of interest, but. Tom Mumley noted the limited data available for PBDEs. Miriam suggested taking a step back from constraints with inputs and considering other options such as whether the model could indicate data gaps and where to best target monitoring. Derek indicated PFOS, because it is ionizable, would be harder to model, and that hydrophobic compounds might be easier. Miriam Diamond also mentioned consideration of OPEs, as she has done some modeling of these compounds. She also suggested QACs, and noted the need for a model that considers biota too. Jay Davis noted bioaccumulation will be a component of the in-Bay model. Kelly brought up PFAS again. Miriam indicated that the physical properties and transformation rates are variable across PFAS and they are generally not well behaved compared to other classes. Similar cautions came up for QACs.

10. Information: Setting the Stage for Day 2

Rebecca Sutton thanked the group for their focused, productive discussion, and then reviewed the schedule and goals for the following day. She spotlighted the joint ECWG and SPLWG during the first half of the second day, and the review and prioritization of special study proposals.

FINAL

Joint Meeting of Emerging Contaminants Workgroup & Sources, Pathways, and Loadings Workgroup

April 20, 2023
San Francisco Estuary Institute

Meeting Summary

Science Advisors *(ECWG shaded in blue; SPLWG shaded in grey)*	**Affiliation**	**Present**
Bill Arnold	University of Minnesota	Yes
Miriam Diamond	University of Toronto	Yes
Lee Ferguson	Duke University	Yes
Derek Muir	Environment and Climate Change Canada	Yes
Heather Stapleton	Duke University	Yes
Dan Villeneuve	U.S. Environmental Protection Agency	Yes
Robert Budd	CA Department of Pesticide Regulation	Yes
Jon Butcher	Tetra Tech	Yes
Steven Corsi	US Geological Survey	Yes
Tom Jobes	Independent Consultant	Yes

Attendees

Adam Wong (SFEI)
Alicia Gilbreath (SFEI)
Amy Kleckner (SFEI)
Anne Balis (City of San Jose)
Anne Cooper Doherty (DTSC)
Autumn Ross (SFPUC)
Ben Priest (CIL)
Blake Brown (CCCSD)
Bonnie de Berry (EOA)
Bushra Khan (UC Davis MPSL)
Craig Jones (Integral)
Daniel Lee (Geosyntec)
David Peterson (SFEI)
Diana Lin (SFEI)
Don Yee (SFEI)
Ed Kolodziej (U of Washington)
Elana Varner (DPR)
Emily Corwin (FSSD/Solano Stormwater

Alliance)
Eric Dunlavey (City of SJ)
Erica Kalve (SWRCB)
Ezra Miller (SFEI)
Gaurav Mittal (SFBRWQCB)
Hope Taylor (Sacramento County Water Resources Dept)
Ian Wren (SF Baykeeper)
Jay Davis (SFEI)
Jaylyn Babitch (City of San Jose)
Jennifer Doughtery (SFEI)
Jennifer Teerlink (DPR)
June-Soo Park (DTSC)
Kayli Peterson (U of Charleston)
Kelly Moran (SFEI)
Lester McKee (SFEI)
Lisa Austin (Geosyntec)
Lisa Welsh (Geosyntec)
Maggie Monahan (SFBRWQCB)
Manoela de Orte (SWRCB)
Martin Trinh (SFEI)
Mary Cousins (BACWA)
Maya McInerney (SFBRWQCB)
Meltem Musa (OEHHA)
Million Woudneh (SGS AXYS)
Miguel Mendez (SFEI)
OIMA staff (SWRCB)
Paul Salop (Applied Marine Sciences)
Pedro Avellaneda (SFEI)
Rachel Scholes (Univ. British Columbia)
Rebecca Sutton (SFEI)
Reid Bogert (C/CAG)
Richard Grace (SGS AXYS)
Rob Carson (Marin Countywide Stormwater)
Robert Budd (CDPR)
Sarabeth George (SCWRB)
Setenay Frucht (SWRCB)
Sami Harper (SFBRWQCB)
Simona Balan (DTSC)
Simret Yigzaw (City of San Jose)
Steven Corsi (USGS)
Tan Zi (SFEI)
Terry Grim (independent)
Tom Mumley (SFBRWQCB)
Violet Renick (Orange County Sanitation)
Xueyuan (Helen) Yu (Central Valley RWQCB)?
Xin Xu (EBMUD)

10. Information: Summary of Day 1 and Goals for Day 2

Amy Kleckner began the day by reviewing meeting tips for live and remote attendees, highlighting important Zoom features, and allowing time for an abbreviated roll call of the day's attendees. Amy then briefly recapped the events of Day 1 of the ECWG meeting, which led into the agenda and goals for Day 2. The first half of Day 2 was a combined meeting of the SPLWG and ECWG, centering the collaboration across the groups, and the second half focused on the prioritization of special study proposals from ECWG.

11. Information: Stormwater CECs Screening Study Preliminary Findings

Rebecca Sutton reviewed preliminary findings from the multi-year screening study of a diverse set of CECs in SF Bay urban stormwater. This study has been a 4-year effort in sample and data collection to understand the occurrence of a broad range of CECs in urban stormwater and overall help fill data gaps for this important pathway of contaminants to the Bay. Rebecca noted that a total of 25 sites were selected based on general site selection criteria including a minimum drainage area of 1 km^2, leveraged legacy contaminant monitoring, and relative urban land use, with 21 sites being highly urban (>80% urban land use) and 4 less urban sites (<20% urban land usage). Sampling occurred when storms were forecast to have a minimum of 1.3 cm of rainfall within 6 hours, with some samples taken from the first event in the season. Five contaminant classes (PFAS, organophosphate esters (OPEs),bisphenols, ethoxylated surfactants, and tire & roadway contaminants) and over 240 individual compounds were analyzed via multiple academic and commercial analytical partners.

Rebecca continued by highlighting the preliminary results of PFAS, organophosphate esters, and 6PPDQ in urban stormwater. A high priority set of contaminants at both the state and federal level, PFAS are used in a plethora of consumer and industrial products and are known to be persistent, bioaccumulative, and highly toxic. PFAS were widely detected; PFOS and PFOA, two of the most well studied PFAS contaminants, along with another PFAS, PFHxA,showed the highest concentrations among those detected. She noted concentrations of PFAS in urban stormwater are comparable to those appearing in municipal wastewater, another important pathway to the Bay. She continued with discussion of OPEs, mobile and toxic chemicals used as flame retardants and plastic ingredients. Several OPEs were detected in stormwater with two OPEs (TBOEP and TCIPP) at the highest concentrations. Also observed in stormwater were two OPEs previously detected at levels exceeding toxicity thresholds in Bay water, TDCIPP and TPhP. There was some variation in the detection of OPEs across sites, with specific OPEs in the thousands of ng/L. Isopropylated and tert-butylated triphenylphosphate esters (ITPs & TBPPs), novel OPEs recently identified in commercial flame retardant mixtures, were also detected in many sites. Rebecca then talked about 6PPDQ, a contaminant derived from a common tire antiozonant ingredient (6PPD), now known to be acutely toxic to multiple fish species at low levels, and under potential regulation through the CA Department of Toxic Substances Safer Consumer Products Program (for vehicle tires containing 6PPD). Levels in the Bay may be of concern, especially with several surpassing a suggested interim PNEC of 10 ng/L for rainbow trout (an important species relevant to the Bay).

Rebecca briefly reviewed the problems with several of the “reference” sites, spotlighting the detection of many CECs in these sites. Though the current process examined watersheds with <20% urban area overall, in some cases sampling sites were located near specific urban land uses (e.g., highways) that are clearly impacting these sites. Future site selection will include more robust analysis to ensure the suitability of sites as less-urban or reference sites.

Overall, these results showed many CECs are present in stormwater, with variations within and between chemical classes. There is a continued need for data and conceptual models to inform future monitoring strategies, particularly as it pertains to supporting urban runoffmodeling. Rebecca ended by summarizing the ongoing efforts in analyzing the stormwater dataset including examination of the influence of storm size, watershed and landscape features, comparison to Bay wet season data, and assessment of variability. A manuscript and summary for managers are expected to be completed by Fall 2023.

Several meeting participants asked questions and discussed this study, with Miriam Diamond recommending the creation of a foundational stormwater model across all contaminant classes that can then be crafted to emphasize different inputs for each class. Many participants emphasized the need for improved spatial analysis and understanding of the connection of sources to sampled sites. Lee Ferguson highlighted the potential for consideration of the ratio of transformation products and the freshness of the stormwater samples. Miriam Diamond and Bill Arnold noted potential complicating factors to this analysis including antecedent dry days and the limited understanding of photodegradation. Tom Jobes mentioned the importance of understanding sources and their relative contribution to best target monitoring and modeling efforts. Jon Butcher added the potential for fugacity modeling including roadway factors among other chemical and physical properties could be useful. Tom Mumley noted a need for understanding the loadings of these contaminants into the Bay for better comparison across pathways. Derek Muir recommended consideration of rainfall sampling to understand background contamination levels. Dan Villeneuve added that comparison of data from baseline events in the dry season to large loads of stormwater could be useful. Dan also inquired if the Bay RMP considered ecological impacts of pathways and watersheds, which Tom Mumley noted was outside of the scope of current Bay RMP design focused on Bay water.

12. Discussion: Stormwater CECs Groundwork - Management Level Review

Kelly Moran presented a management level review of the important groundwork needed to best develop and establish the stormwater CECs approach centered on integrated modeling and monitoring. She noted a subgroup of RMP stakeholders and science advisors, including a mix of experts in CECs and watershed monitoring and modeling, known as the Stormwater CECs Stakeholder Science Advisor Team (SST), are providing guidance on the development of the overall approach. Kelly continued by discussing the relevant management context and actions related to stormwater in the Bay. At present, there are no immediate regulatory drivers for stormwater (CECs) monitoring and management, though that could change in the near future. There is a general regulatory goal of protection of the Bay's beneficial uses. Kelly highlighted PFAS as a contaminant class that has garnered increasing regulatory and stakeholder interest in the past few years. Currently, there are several relevant actions for emerging contaminants across regional, state, and federal agencies including California State and Regional Water Board efforts on CECs, the DTSC Safer Consumer Products Program, the Municipal Regional Stormwater Permit (MRP), and voluntary early management interventions by local agencies. Notably, there is potential for PFAS in the Bay to be added to the §303(d) list of impaired waters in a future Clean Water Act §305(b) Integrated Report. . There are currently no CECs on the 303d listing, but any inclusion would merit reexamination and likely elevation under the RMP tiered risk-based framework. Richard noted that microplastics are on the “watchlist” for the Bay and pesticides are not included here since we are working with DPR on related monitoring projects.

Kelly then reviewed the current budget planning guidance for stormwater CECs modeling and monitoring provided by the SST, which recommended a planning budget of $400k/year for the next three years. This budget includes $300k from the RMP per year (which includes $100k from BAMSC for CECs monitoring) as well as $100k from an EPA Water Quality Improvement Fund Grant. As a note, costs related to remote samplers will be funded separately (e.g., as a separate special study).

Kelly summarized the near term priority management guidance developed in consultations with the SST, which includes three near-term priority topics: loads, changes, and sources of CECs. The SST recommended that the stormwater CECs monitoring design also address two additional considerations. First, it should support addressing the RMP's overarching Management Questions through linkage to the ECWG Management Questions and wet season elements of the Bay Status and Trends monitoring design. Second, it should provide the ability to determine if previously unmonitored CECs are present in local watershed runoff.

With general agreement on the summarized management guidance from participants, Kelly went through the specific suggested near-term priority stormwater CECs management questions for any comments or recommendations. The management question regarding load estimates (*How does the local watershed runoff load to San Francisco Bay compare to loads from other pathways?)* was the first examined, with Miriam Diamond noting its importance and the need to examine temporal variability, particularly through calibration with S&T redesign (with monitoring in dry and wet seasons). Lee Ferguson commented on current sampling design, specifically if selected sites provide enough coverage to accurately estimate/understand contaminant loads to the Bay, and what criteria would tell us that we have enough information for estimates. Tom Mumley similarly remarked on the scope of analysis for load estimates, with Kelly noting these are important needs to identify and continue to think about further within the context of the finalized question.

The next management question presented focuses on change of concentrations/trends (*a. Are presence or concentration in local watershed runoff changing over time? b. Are presence, concentration, or load expected to change in the future?*) following a "trends light concept" where datasets would provide multi-year insights without a requirement for statistically significant trends. This question groups past, current, and future concentrations together, which after some discussion the group agreed was appropriate. Richard Looker commented on the connection between this question and discussion of a similar approach to trends analysis related to the S&T redesign, with potential for a special study to incorporate relevant Bay data, watershed, and source data into a more comprehensive approach.

The third management question reviewed centered on sources (*a. What are the likely sources? b. What land features correlate with presence, concentration, and load in runoff?*), with focus on true sources including products and contaminated sites with consideration of all pathways between source and stormwater runoff. Lee Ferguson inquired about the land features under consideration and inclusion of specific chemicals related to industries. Tan Zi noted many land features, such as land use, land cover, road density, and population, would be included, with Kelly Moran highlighting the availability of data that could provide further analysis and connection to sources as determined per contaminant class. All participants reached a unanimous consensus on moving forward with the current management questions.

13. Information: Stormwater Groundwork Project Update

Kelly Moran kicked off the update on the stormwater CECs groundwork project, beginning with an overview of the three groundwork project elements and their relationships to the five other stormwater CECs-related projects currently underway. The overall stormwater CECs approach aims to integrate modeling and monitoring together to help inform management actions. This is a holistic process meant to examine all aspects of both monitoring and modeling, with the current groundwork project providing critical pieces in the group of related projects that together form the basis for the RMP develop the best monitoring approach possible for stormwater CECs. Kelly introduced the project updates, first an update by Tan Zi on the stormwater CECs loads modeling exploration project and groundwork project stormwater CECs data analysis task, an update from Alicia Gilbreath on the groundwork project stormwater sampling locations database development task, and an update from Don Yee on the groundwork project task to develop a remote stormwater sampler.

Tan Zi continued by updating the group on the progress related to stormwater CECs loads modeling exploration and obtaining insights on monitoring design through stormwater CECs data analysis. The outcomes of these efforts will feed into, the development of a stormwater CECs modeling plan, the next step that is planned for early fall.. An examination of the literature revealed few relevant studies and no existing stormwater CECs modeling template ready to adapt to the Bay Area. Tan continued by reviewing some models used by others for CECs load estimation, beginning with a statistical/regression model, LOADEST, used to evaluate single watershed downstream from a known CEC (PFAS) production facility. This particular model is hard to adapt to the Bay area due to the complexity of the region's watersheds. A second approach uses a simplified process/relation to correlate chemical load relations to land, storm, and other features and extrapolates these to the whole region to estimate loads. The third model is more advanced, with consideration of the different fate and transport processes occurring within the watershed. Previously, this advanced approach has been applied to single watershed with identified discharges and a large monitoring network of a variety of matrices within the watershed. The second approach appears most viable for the RMP's near-term stormwater CECs watershed modeling needs. There remain further knowledge and data gaps to help bridge with findings. The model exploration outcome and recommended approach are expected in a report this summer.

Tan then presented a preliminary stormwater data analysis for OPEs and bisphenols. The goal of this effort is to inform development of design recommendations for CECs stormwater monitoring and to identify factors that may be useful in load modeling. There are variations of total chemical concentrations across the individual chemicals in the two noted classes, with OPEs concentration variation generally nearly an order of magnitude higher than bisphenols. There were clear spatial variations of total sum of bisphenols, with several sites showing levels well above the average/median concentration, and some sites showing differences based on the storm event. bisphenols A, F, and S (BPA, BPF, BPS) appear to be major contributors of bisphenols concentrations, while OPEs have a more diverse fingerprint across sites. In addition, consideration of partitioning behavior could be important for certain chemical classes, with sites showing variance in partitioning for bisphenols. Moving forward, watershed and storm characteristics will be examined to elucidate any relationships from the stormater CEC screening project data and to develop recommendations for the stormwater CECs monitoring and modeling approach.

Alicia Gilbreath reviewed the progress of the sampling locations database, which she is setting up with the help of David Peterson. They identified an initial candidate list of 225 locations in the Bay Area with flow gauges (in collaboration with the RWB). From these, 70 sites with flow gauges were identified for site reconnaissance to understand feasibility of monitoring based on location within key areas of interest, estimated urban area >33%, and no tidal influences. So far, Alicia (and the stormwater team) have visited 19 sites with the rest to be completed this summer. Alicia notes the importance of this work as valuable for all RMP stormwater monitoring (not just CECs) and to support the first region in the world to establish an ongoing regional stormwater monitoring program.

Don Yee then presented on the development of a remote sampler, highlighting the current challenges facing stormwater monitoring including staffing difficulties, hazardous conditions, and imperfect prediction of rain events as well as several other issues. Commerical autosamplers (e.g., ISCO) are available, though they are bulky, expensive, require proprietary parts, and are limited in programming flexibility. Based on an initial autosampler model from USEPA, Don created an SFEI variant fit to meet our specific needs for stormwater monitoring. With the prototype complete, several mounting configurations were considered and tested, including fixed mountings and a semi-fixed pendant mounting using a PVC pipe and 50 lb weight plate to provide suitable collection and stability during a storm. Future work to examine the feasibility of using this sampler for CECs will focus on blank testing the remote sampler for four CECs classes, refining the tidal site adjustment to best determine set-up times, and adding remote programming to change capabilities. Several participants were excited about the progress with Richard Looker wondering about the cost. Don roughly estimated that it would be roughly $6k of total cost per sampler, including about $1500 in raw parts. Compared to an ISCO sampler, Don noted the cost was above $3k though it is actually upwards of $6k as a base cost and not any additional add-on features.

14. Summary of Proposed ECWG Special Studies for 2024

Rebecca Sutton gave an overview of all proposed special studies, highlighting the motivation and approach for each study, as well as associated budgets and deliverables. Meeting participants were allowed a few clarifying questions after the presentation of each proposal, though it was noted that more time would be available for discussion in the next agenda item. The focus of discussion was on seven high-priority proposals, one of which is already expected to be funded through RMP S&T, with a brief review of two special study proposals relevant to ECWG from other RMP workgroups: SPLWG and PCBWG.

The proposal for Stormwater CECs Monitoring and Modeling in 2024 is a placeholder for completing and implementing the novel integrated monitoring and modeling plan in the upcoming wet season (2023/24). This project continues the work of the Stormwater CECs Stakeholder-Science Advisor Team (SST) and will be developed together with the Stormwater CECs Approach. The proposal also requests early release of funds for this project to begin in this summer (2023).

Next, the PFAS Synthesis & Strategy proposal highlights an important updated review of the current state of the science of PFAS in the Bay, the development of a conceptual model framework for sources to the Bay, and an updated strategy for RMP monitoring of PFAS. This proposal would include a concise literature review to inform interpretation of current PFAS data and help further identify priority information gaps to best inform future monitoring. Several members had questions about the scope of the project, specifically on the definition of PFAS to be used in the project, and whether sub-categories such as pharmaceuticals and pesticides will be included. Kelly Moran noted this project would use elementary concepts to first develop a conceptual model as a base of understanding PFAS in the Bay. Tom Mumley indicated that if this project could potentially be spread over two years due to on-going projects, that would be important to include.

PFAS and non-targeted analysis of marine mammal tissues, the second of a two-year study, was showcased next. This study aims to inform S&T study design by determining if it is appropriate to add routine monitoring of marine mammal tissues while monitoring PFAS, a contaminant of high priority. In addition, improved analytical methods, particularly for non-targeted analysis, are likely to provide new insights into the presence of CECs in marine mammal tissues. The first year of this study has been funded as a part of S&T efforts.

The next proposal discussed would expand on current S&T efforts to monitor PFAS with additional analysis using the total oxidizable precursors (TOP) assay in Bay water and sediment. The use of the TOP assay provides a means to indirectly quantify presence of a broader suite of PFAS precursors that break down to detectable compounds, providing a greater scope of PFAS present beyond a targeted method alone. The study could be spread across both wet and dry seasons, with three different funding levels available, and would require early release of funds to begin in summer 2023. A few meeting participants asked for clarification on the TOP sites, which will be correlated with S&T sites for targeted PFAS analysis. Others also asked about archiving samples, which Rebecca Sutton noted is also an option.

The next study was the third and final year in a multi-year monitoring effort to examine tire contaminants in Bay water during the wet season. A small number of samples have indicated the presence of the tire contaminant 6PPD-quinone and others in Bay water, with further results needed to classify these contaminants under the tiered risk-based framework. In addition, these findings can help evaluate the pilot wet season monitoring effort.

A proposal to examine OPEs, bisphenols, and other plastic additives in wastewater effluent was introduced to build our understanding of the fate and transport of these contaminants in the Bay. Limited previous findings of OPEs and bisphenols in wastewater, stormwater, and ambient Bay water merit further review to assess the importance of the effluent pathway while expanding analysis to additional classes of plastic additives potentially reaching the Bay. This study is presented in two tiers based on interest to examine only OPEs, which are expected to be of High Concern under the revised tiered risk-based framework, and the full suite of contaminant classes.

The final project presented was the first year of a two-year study on non-targeted analysis (NTA) of SF Bay fish. This study would leverage 2024 S&T sport fish monitoring to collect samples for NTA. This type of analysis will provide a means to identify unanticipated contaminants, including unknown PFAS and halogenated hydrophobic (bioaccumulative) compounds, that may merit follow-up targeted monitoring, and would provide the means to compare San Francisco Bay fish contaminant profiles to those of fish in the Great Lakes, where this type of study has already occurred. Derek Muir noted that the analytical lab partner uses advanced analytical equipment, which may be able to detect additional contaminants like chlorinated paraffins. Heather Stapleton inquired if the sportfish study would be more human or ecologically focused, with Rebecca noting the study is on consumable fish tissues (e.g., fillets) and is meant to inform human and ecological health.

15. Discussion of Recommended Studies for 2023 - General Q&A, Prioritization

Amy Kleckner introduced the item by reviewing the process for prioritization and recommendation of special study proposals. She also noted the overall planning budget for the special studies to prioritize for the TRC and overall scope of the budget within the RMP. Meeting attendees asked any remaining questions while proposal PIs were still in attendance.

Stormwater CECs Monitoring and Modeling
Tom Mumley mentioned the stormwater proposal has many gaps remaining in what will be done and inquired what optimum use is needed now. Kelly Moran clarified the importance of building a strong foundation for the program in concert with what is occurring in the stormwater CECs approach. Bill Arnold inquired if there is flexibility in the analytes included in the study, which Kelly noted is possible, depending on funding levels.

PFAS Synthesis & Strategy
Several attendees continued discussion of the best time to begin this project, with several noting the current value of the synthesis and development of a plan to continue updating the document. Rebecca Sutton noted this is an ideal time to start as a wide variety of our work is now centered around PFAS and it is critical to best inform our continued projects. She continued by noting this would help provide information on important data gaps and considers the document to be “living,” transforming as more data is available. Kelly Moran also noted the possibility to do a WQIF proposal for PFAS in the Bay to add more funds to this effort.

PFAS and Non-Targeted Analysis of Marine Mammal Tissues
Several attendees asked about year 1 results. Rebecca Sutton explained that no tissue analysis has happened yet, as harbor seal pup season is in the spring and we are waiting for more samples to be collected before sending them to the labs.

PFAS in Bay Water & Sediment using the TOP Assay
Several meeting attendees asked about the extraction method and its relation to sediment. Diana Lin described the solid phase extraction method, which Lee Fergson noted could be undercounting PFAS. He also mentioned consideration of the direct-TOP method to directly oxidize the sediment and get a full understanding of PFAS present. Tom Mumley inquired about the current importance beyond intellectual interest, which Derek Muir noted is important to consider as PFAS precursors have been observed in sediment and could be degrading to relevant contaminants. Lee Ferguson also noted it could be important to consider the high loadings from wastewater and if they are degrading or partitioning to sediments. Miriam

Diamond noted consideration of doing wet and dry season monitoring for wastewater sampling to understand if there is a difference in seasonality.

Tire Contaminants in Bay Water (Year 3/3)
Some participants asked whether the dry season should be monitored as well as the wet season (only wet season was proposed). Kelly Moran explained that tire-related chemicals were non-detected or very low concentrations in the dry season of year 1, which is why only wet season monitoring is being conducted this year and has been proposed for year 3. Whether a third year of the project is necessary was also brought up; while we have two years of data, the S&T wet season pilot is for three years and a third year's data would be helpful toward informing our understanding of these chemicals and to support inclusion of tire contaminants in Bay modeling.

OPEs, Bisphenols, and Other Plastic Additives in Wastewater
Several experts, led by Derek Muir, indicated a high interest in the option to gather data on the broader list of plastic ingredients, rather than focusing exclusively on OPEs.

Non-targeted Analysis of San Francisco Bay Fish (Year 1/2)
Stakeholders indicated an initial interest in reducing the requested budget, pondering whether this might impact the overall study design, and whether a portion of the budget for the first year could be covered via S&T. Tom Mumley indicated that S&T should fund collection of extra fish tissue to archive.

16. Closed Session - Decision: Recommendations for 2023 Special Studies Funding

Study Name	Budget	Modified Budget	Priority	Comments
Stormwater Contaminants of Emerging Concern (CECs) Monitoring and Modeling 2024	\$300,000 (RMP) \$100,000 (WQIF)		1	Leveraging additional funding and in year 3
PFAS Synthesis & Strategy	\$107,000		4	When is the right time to do this? We may want to wait for more data Eventual consensus that sooner is better Maybe a lit review is necessary first, others say not as critical Could produce technical manucript Clarify scope of PFAS to include
PFAS and Nontargeted Analysis of Marine Mammal Tissues Year 2	\$126,500			

PFAS in Bay Water & Sediment using the TOP Assay	$27,200 (Wet Season; Water only) $67,200 (Dry & Wet Seasons; Water only) $97,700 (Dry & Wet Seasons; Water & Sed)	$67,200 (Dry & Wet Seasons; Water only)	5	Qualms about methods for sediment TOP, Advocates for Middle Option- Will be interesting from a PFAS standpoint Interested in potential presence of precursors Think about Eurofins for analysis - Becky says Eurofins much more expensive
Tire and Roadway Contaminants in Wet Season Bay Water Year 3	$50,000		2	
OPEs, Bisphenols, and Other Plastic Additives in Wastewater	$48,400 (OPEs only) $95,400 (OPEs, Bisphenols, and Other Plastic Additives)	$95,400 (OPEs, Bisphenols, and Other Plastic Additives	3	
Non-targeted Analysis of San Francisco Bay Fish Year 1	$48,000 ($110,000 for both years)	$23,000 ($85,000 for both years)	6	Some advisors advocate to deprioritize, but others believe this study is complementary, program could stop after one year Cover sample collection ($25K) under the S&T fish monitoring budget (so it doesn't need to be included here) Could do lite version even if not preferred Could fund analysis of archived samples in subsequent years

17. Report out on Recommendations

After the closed door session, proposal authors were invited back to the meeting to hear the final prioritization decisions. Eric Dunlavey summarized the discussed suggestions and recommendations. The proposals for OPEs and plastic additives was of high interest due to its broad scope of analytes and prioritized. The PFAS Synthesis and Strategy was the next highest priority due to its need, though questions remained about the most appropriate time, clarification of overall scope, and potential development of a manuscript. The proposal on TOP PFAS in Bay water and sediment was next with exclusion of the sediment due to questions of the current analytical method and potential for analysis by another lab. The proposal on NTA in fish was last, with advisors noting a need to collect archived fish and fund analysis in future years.

<u>Adjourn</u>

About the RMP

RMP ORIGIN AND PURPOSE

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.

RMP PLANNING

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

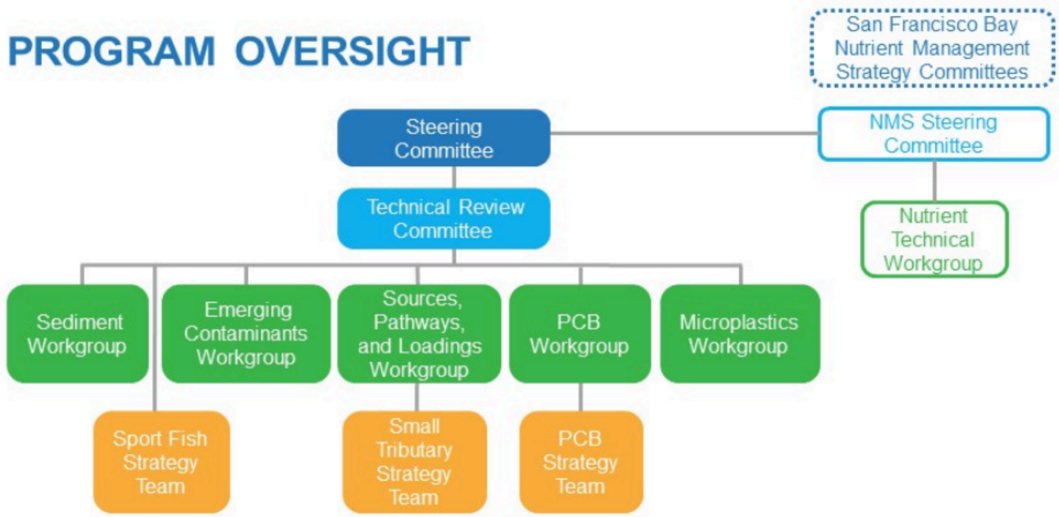
The annual planning cycle begins with a workshop in October in which the Steering Committee articulates general priorities among the information needs on water quality topics of concern. In the second quarter of the following year the workgroups and strategy teams forward recommendations for study plans 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.

Figure 1. Collaboration and adaptation in the RMP is achieved through the engagement of stakeholders and scientists in frequent committee and workgroup meetings.



The Steering Committee consists of representatives from discharger groups (wastewater, stormwater, dredging, industrial) and regulatory agencies (Regional Water Board and U.S. Army Corps of Engineers). The Steering Committee determines the overall budget and allocation of program funds, tracks progress, and provides direction to the Program from a manager's perspective.

Oversight of the technical content and quality of the RMP is provided by the **Technical Review Committee** (TRC), which provides recommendations to the Steering Committee.

Workgroups report to the TRC and address the main technical subject areas covered by the RMP. The Nutrient Technical Workgroup was established as part of the committee structure of a separate effort—the Nutrient Management Strategy—and makes recommendations to the RMP committees on the use of the RMP funds that support nutrient studies. The workgroups consist of regional scientists and regulators and invited scientists recognized as authorities in the field. The workgroups directly guide planning and implementation of special studies.

RMP strategy teams constitute one more layer of planning activity. These stakeholder groups meet as needed to develop long-term RMP study plans for addressing high priority topics.

Emerging Contaminants Strategy for 2025

Summary: Increasing interest in emerging contaminants from the San Francisco Bay Regional Water Board, RMP stakeholders, and the general public is reflected in headline news and management actions at local, state, and federal levels. The staff and effort needed to manage the RMP's CECs focus area has increased significantly in recent years. For the RMP CEC Strategy to remain relevant and timely, it needs to be updated annually with new information and study findings from the RMP and others. In addition, a higher level of coordination and integration within and across workgroups is essential to optimize RMP resources.

Core deliverables include tracking new information regarding contaminant sources, occurrence, and toxicity and updating the RMP's tiered risk-based framework via an ECWG presentation and, as appropriate, a CEC Strategy Update document; responding to requests for information from the Water Board, state agencies, and RMP stakeholders; and coordinating pro bono analyses by partners. To accomplish all of these tasks, $70,000 is requested.

Estimated Cost: $70,000
Oversight Group: ECWG
Proposed by: Rebecca Sutton (SFEI)
Time Sensitive: Yes

TASKS AND TIMELINE

Deliverable	Due Date
Task 1. Information gathering on contaminant sources, occurrence, and toxicology from a variety of sources (e.g., literature review, scientific conferences) throughout the year to inform Task 4	Year-round
Task 2. Assistance to the Water Board and other RMP stakeholders concerning scientific information and presentations relating to emerging contaminants	Year-round
Task 3. Coordination of pro bono studies conducted in collaboration with Status and Trends monitoring activities	Year-round
Task 4. Updates to the RMP CEC tiered risk-based framework and related documents; presentation at spring ECWG meeting	Spring 2026

Special Study Proposal: Stormwater Contaminants of Emerging Concern (CECs) Monitoring and Modeling 2025

Summary: This project will continue implementing the RMP stormwater CECs integrated monitoring and modeling program in water year 2025 (October 2024-September 2025). It builds on prior stormwater CECs RMP projects that have identified priority near-term management questions, identified the modeling and data analysis approach to address these management questions, developed and piloted the SFEI Mayfly remote sampler, and are currently framing out the RMP stormwater CECs monitoring design. These projects are collecting data and supporting the overall stormwater CECs monitoring program framework development through the RMP "Stormwater CECs Approach" project that is slated for completion in late 2024. This program is being guided by a Stormwater CECs Stakeholder-Science Advisor Team (SST). The SST includes representatives from the Steering Committee and Technical Review Committee, as well as science advisors and stakeholders.

This project is designed to mesh with two RMP-related grant projects funded by EPA's San Francisco Bay Water Quality Improvement Fund (WQIF): Destination Clean Bay and PFAS Sources to Solutions. This project is supported by a separate, approved 2024 RMP project for purchasing and/or building remote samplers capable of collecting stormwater during storm events ("remote sampler purchase project"). This proposal includes a range of costs to prove the option to expand its scope should additional funds become available to the RMP from the EPA Program Office.

We request early release of funds to initiate implementation of this project in summer 2024 to ensure we can be prepared for the fall start of the wet season.

Estimated Cost:	$300,000 (base RMP funding) - $450,000 (including Tier 2 funding)
Oversight Group:	ECWG and SPLWG, Stormwater CECs Stakeholder-Science Advisor Team
Proposed by:	Kelly Moran, Alicia Gilbreath, Pedro Avellaneda, Don Yee, Rebecca Sutton
Time Sensitive:	Yes

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Project management and coordination with non-RMP funding sources	Fall 2024-Fall 2025
Task 2. Stakeholder and science advisor engagement —Informal stakeholder and advisor meetings —One SST meeting —Three RMP presentations (ECWG/SPLWG, TRC and SC)	 Fall 2024-Fall 2025 Summer-Fall 2025 Spring 2025
Task 3. CEC modeling and data analysis —Inform monitoring design	 Summer 2025

—Draft Technical Report —Final Technical Report	October 31, 2025 December 12, 2025
Task 4. Stormwater CECs work integrated scientific systems development and cross-task and cross-project team coordination	Fall 2024-Summer 2025
Task 5. Stormwater CECs monitoring —ECWG and SPLWG presentations —Presentation to and discussion with the SST —Data uploaded to CEDEN	 Spring 2025 Summer-Fall 2025 December 2025
Task 6. Remote Sampler continued improvement —ECWG and SPLWG updates —Updated sampler design summary	 Spring 2025 December 2025
Task 7. Initiate site selection and permitting for water year 2026	Summer 2025

Background

CECs are a diverse group of substances with different sources, chemical properties, and fate. A multi-year RMP stormwater CECs monitoring project identified the presence of CECs in urban stormwater runoff (Peter et al., submitted; Tian et al., 2021). Available data from this and other RMP CECs sampling are relatively limited, but provide a strong weight of evidence that stormwater is a major pathway for many CECs to enter San Francisco Bay. Importantly, prior to water year 2024, RMP CECs monitoring, which has focused on understanding the potential for CECs to occur in stormwater, has not been designed to address other management questions, such as estimating loads of CECs discharged to the Bay.

The RMP is developing a stormwater CECs monitoring approach that addresses both Emerging Contaminant Workgroup (ECWG) and Sources, Pathways, and Loadings Workgroup (SPLWG) management questions. A cornerstone of the new stormwater CECs monitoring approach is the integration of monitoring and modeling 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 increase the number of samples that can be collected during each storm event. Through the deployment of remote samplers, more data can be obtained in a more diverse array of locations as compared to manual sampling.

The near-term focus is on developing a modeling and monitoring approach to answer three near-term priority management questions:

1. Load. How does the local watershed runoff load to San Francisco Bay compare to loads from other pathways?

   This entails order-of-magnitude load estimates and is interpreted in the context of Bay management questions, which guide the RMP efforts to consider chemical fate, organism exposures, and exposure timing in the Bay.

2. Changes. (a) Are presence or concentration in local watershed runoff changing over time? (b) Are presence, concentration, or load expected to change in the future?

   This is a “trends light” concept, which would provide insights on a multi-year time scale while not requiring datasets robust enough to identify statistically significant trends.

3. Sources. (a) What are the likely sources? (b) What land features correlate with presence, concentration, and load in runoff?

   “Sources” is defined as true sources, such as products and contaminated sites and includes consideration of all pathways between source and stormwater runoff, including air deposition and groundwater transport.

This project depends on work in progress on multiple projects currently underway including the 2023 Stormwater CECs Approach project (anticipated completion in 2024) and the Stormwater CECs Modeling & Monitoring 2024 project (remote sampler improvements; CEC modeling plan; pilot stormwater CECs monitoring). Consequently, some elements of the necessary work remain in flux and will be refined in consultation with the SST as the project proceeds.

This project is being integrated with two RMP-related grant projects. The recently initiated “Destination Clean Bay” project is a multi-faceted Bay monitoring and modeling project funded by EPA’s SF Bay Water Quality Improvement Fund (WQIF) 2022. It will use the monitoring data generated by this project to support watershed and Bay model development. The EPA WQIF 2023 “PFAS Sources to Solutions” project is expected to start in summer 2024. It integrates stormwater, wastewater, and Bay monitoring, conceptual modeling, stormwater and wastewater preliminary loads modeling, data analysis, and commercial product PFAS testing toward the goal of informing management action, including prioritizing PFAS-containing products for potential regulatory action under California’s Safer Consumer Products Program.

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	N/A
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Implement CECs integrated monitoring and modeling and move from piloting to full use of remote samplers.	Implementing monitoring projects to address near-term priority stormwater CECs management questions, such as to determine whether stormwater pathway loads of various CEC families are large or small relative to other pathways flowing into the Bay.
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	N/A
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	Conduct monitoring capable of informing general understanding of changes in CECs presence in the stormwater pathway.	Understanding the changes in presence of CECs in the stormwater pathway.
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A
6) What are the effects of management actions?	N/A	N/A

Approach

In water year 2025, we propose to complete piloting and preparations for full implementation of the new Stormwater CECs Monitoring and Modeling Approach. The

Approach will involve use of remote samplers and will integrate monitoring and modeling designs.

During water year 2024, we have been refining the design of the SFEI Mayfly remote sampler and pilot testing it in house and at various stormwater monitoring locations. Through these pilot tests and deployments we have been refining processes for remote sampler programming, mounting options, and efficient installation and retrieval. The pilots have clarified the types of locations feasible for the Mayfly. Due to unanticipated challenges with obtaining stormwater sampling location permits, this year's piloting was less robust than we had planned. During the upcoming wet season, we anticipate expanded pilot work and preparing to transition from pilot-scale to full implementation of the SFEI Mayfly monitoring.

Blank testing of the SFEI Mayfly and a larger, more traditional remote sampler (ISCO) revealed contamination of samples by a few bisphenol and organophosphate ester (OPE) chemicals (SGS AXYS tested for OPEs, bisphenols, and PFAS - see Yee et al. 2024 for analyte lists; the Kolodziej laboratory tested for other stormwater CECs including 6PPD-quinone - see vehicle/tire-related suite from Hou et al., 2019). Negligible PFAS contamination was identified. Both samplers showed similar contamination, suggesting the soft tubing required for their peristaltic pumps as the likely contamination source. While the contamination was limited to a few chemicals, some of these chemicals are risk drivers for the Bay (bisphenol A, and the OPEs TCIPP and TBOEP). Consequently, the SST recommended that the RMP continue with the SFEI Mayfly, starting with PFAS, while in parallel exploring alternative approaches that might avoid contamination.

We completed additional research on soft tubing options, which identified several potential options that Dr. Heather Stapleton (Duke University) is testing for OPE content (no laboratory was identified to conduct a full suite of bisphenols content measurements on tubing samples). We also identified two commercially available, larger (ISCO-comparable) samplers (Manning, Aquamatic) that use vacuum for sample collection instead of peristaltic pumps, thus eliminating contact with soft tubing. We blank-tested both options (analyzing PFAS targeted and TOP, OPEs, bisphenols, and tire/road related chemicals) and are currently awaiting results. We plan to review all of these testing results with the SST to inform sampler design and sampler selection for the upcoming water year.

This proposal does not include costs for activities funded by the related grants. Destination Clean Bay grant funds will pay for laboratory analysis, data management and CEDEN data uploads for stormwater monitoring for non-PFAS chemicals (OPEs, bisphenols, and tire/road chemicals), laboratory analysis for any sampler blank testing, as well as for a portion of SFEI labor.

PFAS Sources to Solutions funds will pay for PFAS conceptual model development (which will support this project's modeling work), laboratory analysis for PFAS in stormwater samples (targeted and TOP), stormwater PFAS data management and data uploads to CEDEN, and travel to share findings at a stormwater or monitoring conference such as the California Stormwater Quality Association (CASQA) Conference in fall 2025.

Task 1: Project management and coordination with non-RMP funding sources
This project will be funded by a minimum of three funding sources (RMP and two EPA WQIF grants), with a potential for funding by an additional source (EPA Program Office 2024). This task will provide SFEI staff with the capacity to coordinate the project's financial and scientific management across three funding sources and the various requirements associated with each funding source.

If additional funding becomes available, additional Task 1 funding will be required to meet the additional funding source requirements, to expand the budget controls, and to help the project team ensure work is properly tracked for each funder.

Task 2: Stakeholder and science advisor engagement
We will convene a meeting of the SST to support model development and to refine the program based on anticipated phased implementation of the monitoring design. We anticipate holding one SST meeting in addition to extensive informal individual and small group engagement with stakeholders and advisors. We will provide a project update at spring 2025 RMP workgroup meeting(s) and plan to share findings at a stormwater or monitoring conference such as the California Stormwater Quality Association (CASQA) Conference in fall 2025.

If additional funding becomes available, this task would be expanded to start the process for selecting a small group of fixed stormwater monitoring locations to support addressing near-term priority CECs management questions and other RMP and stakeholder data needs. This would entail engaging stakeholders and science advisors across RMP workgroups to obtain input toward developing a multi-benefit long-term design and staff time to develop and refine a list of proposed sites.

Task 3: Stormwater CEC modeling and data analysis
This task will implement the first phase recommendations of the 2024 RMP Stormwater CECs Modeling Work Plan task, which is to be completed in late 2024. The CECs modeling work plan will address the “Loads” and “Sources” near-term priority management questions noted above.

The work on this task will be coordinated with the PFAS conceptual model being developed under the PFAS Sources to Solutions grant. Due to the opportunity provided by the PFAS grant, we anticipate that the first implementation for stormwater CECs load modeling will be for PFAS. Specifically, the grant anticipates that SFEI will prepare a technical report “Urban PFAS Loads Estimates” in 2028. The grant also includes substantial work toward identifying PFAS sources, i.e., specific categories of PFAS products most likely to contribute PFAS to San Francisco Bay. The grant workplan includes product research, product PFAS content measurements, the conceptual model identifying pathways between products and San Francisco Bay, and laboratory and data management costs associated with RMP stormwater sampling. SFEI plans to build off the conceptual model and the combined RMP and municipal stormwater PFAS dataset anticipated to be available by 2027 (potentially >100 samples) to use data-driven methods to explore potential linkages between monitoring data and products (most likely by exploring land use/land feature correlations).

To address the loads management question, the 2024 CECs modeling workplan will lay out the first steps to implement the recommendations of the recently completed RMP report *Modeling Stormwater Loads of Contaminants of Emerging Concern: Literature Review and Recommendations* (Avellaneda & Zi, 2024). This report recommended that we use a hybrid data-driven and spatially distributed approach for regional stormwater load estimation and recommended that initial load estimates be made using the RMP's Regional Watershed Spreadsheet Model (RWSM).

We expect the modeling workplan will include updating and adapting the RWSM to support CECs load estimates. Modeling and data analysis for CECs will require extensive work to develop underlying datasets. In response to regional challenges updating Bay Area land use data and the desire to explore land features other than land use, this task would include evaluation of other available datasets, including artificial intelligence enhanced data. Additionally, we anticipate exploring consideration of climatic factors in the data statistical analysis. All of this work would be coordinated with the parallel PFAS conceptual model development.

If additional funds become available, we would expand work on development of underlying datasets. These datasets could include, for example, geospatial information on land features such as directly connected impervious areas, roofing areas identified as a source of PFAS, and solar panel areas. This geospatial information will be used to update the RWSM.

In addition, this task will include providing modeling expertise and preliminary PFAS data analysis to support stormwater sampling location selection for water year 2026 (October 2025 - September 2026). The preliminary data analysis will provide an opportunity to use the information from PFAS product research and the grant-funded PFAS conceptual model to consider how we will address the "sources" management question, specifically "what land features correlate with presence, concentration, and load in runoff?" As only a limited dataset will be available in 2025, such work will not be a focus of 2025 activities, but this early work will inform recommendations for next steps.

To support these novel model development activities, if additional funding becomes available, this task's budget would be expanded to include funding for an expert consultant with expertise on conceptual and stormwater modeling of chemicals in urban outdoor environments to support the SFEI modeling team.

The results of this task will be documented in a report with recommendations for the next phase of this work, which we anticipate conducting in 2026.

<u>Task 4: Stormwater CECs Work Integrated Scientific Systems Development and Cross-Task and Cross-Project Team Coordination</u>

This task includes project team meetings to keep this multi-faceted project on track, to develop operating systems supporting the long-term implementation of integrated stormwater CECs modeling and monitoring (e.g., workflows and shared team physical and digital resources), and to ensure consistency and coordination among the interlinked elements of this and related stormwater and Bay CECs monitoring and modeling projects. We anticipate (almost) biweekly high-level meetings with staff from the emerging contaminants, stormwater monitoring, stormwater modeling, project leadership, and RMP science leadership teams and occasional (every 2-3 months) meetings with a larger group of key scientific staff to work through scientific issues on specific project elements.

<u>Task 5: Stormwater CECs Monitoring</u>

The CECs monitoring approach for water year 2025 entails three elements, using three different sample collection methods: the SFEI Mayfly portable remote sampler; a larger full-sized remote sampler; and manual sampling. The budget range for this task reflects fewer samples at the lower end of the range and more samples (up to the maximum in each category) at the upper end of the range.

The first element entails expanded pilot work and preparing to transition from pilot deployment to water year 2026 full implementation of remote SFEI Mayfly samplers for monitoring PFAS (only). Remaining pilot deployments of the remote samplers will provide necessary real-world experience with larger-scale remote sampler monitoring, starting with smaller deployments (e.g., 2-4 samplers per event) and moving to larger deployments (e.g., up to 8 samplers per event, with a potential stretch goal of 12). The SFEI Mayfly uses soft-sided “cubitainer” samplers. Two containers will be collected by each sampler during each event, one each anticipated to be analyzed by SGS AXYS for PFAS target and total oxidizable precursor [TOP] analysis (see Yee et al. 2024 for analyte lists; lab selection pending completion of grant-related requirements). We anticipate a total of 20 sets of samples (PFAS target and TOP) from 4 or more events.

If additional funding becomes available, we will be able to try for 24 sets of samples (i.e., four additional remote sampler deployments with one PFAS target and one PFAS TOP analysis from each deployment).

The second element, piloting a full-sized sampler to test out the approach for future permanent, fixed location deployments, will involve temporary installation of a large multi-container automated remote sampler (e.g., ISCO peristaltic pump or Manning or Aquamatic vacuum pump), for up to two storm events. The multi-bottle capacity of the samplers will allow collection of samples to be analyzed by SGS AXYS for OPEs, bisphenols, and PFAS target and TOP (see Yee et al. 2024 for analyte lists), by the Kolodziej laboratory for other stormwater CECs including 6PPD-quinone (vehicle/tire-related suite from Hou et al., 2019), and by SFEI staff for suspended sediment concentration (SSC). For all analytes, QA samples will include one field blank, one duplicate sample, and one matrix spike sample.

If additional funding becomes available, we will be able to pilot the sampler during a third storm event, collecting samples for the same analytes listed above.

Both elements one and two will involve training additional staff in remote sampler preparation, programming, deployment, and retrieval methods.

The third element will entail limited manual sampling for multiple contaminants at locations that are infeasible for SFEI Mayfly installation and/or locations that are candidates for future permanent fixed sampling locations. We anticipate two sampling locations, one storm event at each site, 1 to 2 locations per storm event, plus one duplicate and one field blank. Samples collected will be analyzed by SGS AXYS for OPEs, bisphenols, and PFAS target and TOP (see Yee et al. 2024 for analyte lists), by the Kolodziej laboratory for other stormwater CECs including 6PPD-quinone (vehicle/tire-related suite from Hou et al. 2019), and by SFEI staff for suspended sediment concentration (SSC). For all analytes, QA samples will include one field blank and one duplicate sample (we propose to rely on the matrix spike described above).

If additional funding becomes available, we will be able to expand manual sampling to four additional locations, one storm event at each site, collecting samples for the same analytes listed above.

Prior to the initiation of this project, in Summer 2024, we will start identifying sampling locations in consultation with stakeholders and acquire permits to place the remote samplers and work at the selected sites. We anticipate this pre-project work will be funded by the Destination Clean Bay grant. This site selection process will give special focus on sites likely to be candidates for a potential future fixed-station monitoring network.

Additional tasks to implement stormwater monitoring are pre-season storm preparation, staff training, pre-storm remote sampler setup (e.g., programming, tubing installation, battery charging), and cleaning equipment.

After each event, remote sampler installation and performance will be evaluated to inform procedures for subsequent installations. Lessons learned about the installation and use of remote samplers will be incorporated into the Stormwater CECs Approach report, future sampling designs, and (as appropriate) into the sampler refinement work (Task 6).

The Destination Clean Bay and PFAS Sources to Solutions grants will fund QA/QC evaluation of the data and, after QA/QC evaluation, data upload to the California Environmental Data Exchange Network (CEDEN). QA/QC findings will be evaluated in detail to inform future stormwater CECs monitoring design and laboratory analysis. Data interpretation will be limited, focused on evaluating outcomes and informing future monitoring design. We do not anticipate a full report on this year's data, as the Stormwater CECs Approach will establish a multi-year reporting and data interpretation process. PFAS monitoring data will be summarized and included in a 2028 report under the PFAS Sources to Solutions grant.

The study team will evaluate the outcome of the monitoring experience, which will inform future Stormwater CECs monitoring design. Update presentations will be given to the ECWG and SPLWG and results will be reviewed with the SST.

<u>Task 6: Remote Sampler Continued Improvement</u>
This task has two potential elements: SFEI Mayfly improvements and potentially work to prepare for use of vacuum samplers.

SFEI Mayfly improvement tasks may entail blank testing of any promising peristaltic pump soft tubing alternatives, physical modifications of the design based on additional deployment experience, the high priority task of continued exploration of options to add telemetry capabilities for post-installation control of the remote sampler operations, which would simplify programming, provide better ability to respond to changing weather forecast when using the remote samplers, and reduce deployment costs.

If the blank test results for vacuum samplers are promising, this task would include materials and activities to support in-office operational testing (e.g., for pump head height and programming) and their pilot deployment under the task above (e.g., construction of parts to support necessary collection containers, implementing telemetry controls).

If additional sampler blank QA-testing is needed, it will be conducted following procedures similar to those used for the spring 2023 and spring 2024 field blank testing of the current SFEI Mayfly design and the vacuum samplers, i.e., pumping laboratory water through the sampler at a remote location selected to minimize potential environmental contamination (e.g., from ambient air). Field blank samples will be analyzed by SGS AXYS for OPEs, bisphenols, and (if appropriate for the design) PFAS (see Yee et al. 2024 for analyte lists). Field blanks will also be analyzed for other stormwater CECs including 6PPD-quinone (vehicle/tire-related suite from Hou et al. 2019). Data QA review and interpretation will include evaluating samplers for potential contamination and examining pilot data in the context of available stormwater CECs monitoring data. Blank testing analytical costs would be funded by the Destination Clean Bay grant.

If additional funds are available, this task would be expanded to include work toward developing telemetry controls for the full-sized samplers envisioned for installation at fixed stormwater monitoring locations and exploration of a vacuum-based alternative design for the SFEI Mayfly.

Presentations on progress will be given to the ECWG and SPLWG. The scientific team will evaluate the outcome of the sampler improvement effort with the SST to inform the stormwater CECs monitoring design as well as the plan for purchasing and building additional remote samplers under the remote sampler purchase project. If the SFEI Mayfly design is modified, a revised summary of the revised sampler design, with photos, will be prepared.

Task 7. Initiate site selection and permitting for water year 2026.
This task is proposed only if additional funds are available. Efforts to pilot the SFEI Mayfly remote sampler were limited by the long timelines necessary to obtain permits for its temporary installation at sampling locations. Based on this experience, we anticipate the need to start site selection and permitting each year in June to ensure we are prepared for the upcoming wet season. Under this task, in June 2025, we will start identifying sampling locations in consultation with stakeholders and begin acquiring permits/permission to place remote samplers and collect samples at the selected sites. The budget assumes that this task provides seed funding for an early start; storm season preparations will be included in the Stormwater CECs water year 2026 budget.

Budget

The Project budget will include Labor, subcontracted expert advisor services, and direct costs. The budget lists costs to be covered by the DCB ($100,000) and PFAS Source to Solutions ($251,000 - $260,000) grants, but these amounts are not included in the totals which represent only the RMP funding request.

Table 2. Budget

Labor	**2025 - Base (hours)**	**Base + Tier 2 (hours)**	**Tier 2 activities**
Task 1. Project management and coordination with non-RMP funding sources	$20,000 (95)	$30,000 (140)	Increased management complexity with more funding sources
Task 2. Stakeholder and science advisor engagement	$45,000 (215)	$65,000 (310)	Initiate site selection for permanent network
Task 3. Stormwater CEC modeling and data analysis	$55,000 (320)	$70,000 (400)	Increased work on underlying data sets to support modeling and

			data analysis
Task 4. Stormwater CECs work integrated scientific systems development and cross-task team coordination	$35,000 (180)	$35,000 (180)	n/a
Task 5. Stormwater Monitoring Base program max. # of sets of samples: --24 Remote (PFAS target and TOP) --2 Manual & 2 large autosampler (PFAS target and TOP, OPEs, bisphenols, Kolodziej lab tire/road chemicals) --5 QA samples (all analytes)	$145,000 (850)	$199,750 (1,100)	Additional samples (4 remote sets; 4 manual sets; 1 large autosampler set)
Data technical services --PFAS target and TOP (PFAS grant) --OPEs, bisphenols, Kolodziej lab tire/vehicle chemicals (DCB)	$20,000 (120) $31,500 (190)	$20,000 (120) $31,500 (190)	Limited additional work for additional samples
Task 6. Remote sampler continued improvement	$30,000 (150)	$40,000 (200)	More resources to develop telemetry for large samplers; try design for mayfly vacuum sampler
Task 7. Initiate site selection and permitting for water year 2026	$0	$5,000 (30)	Start site selection/ permitting in June
Develop PFAS conceptual model (PFAS grant)	$200,000 (1,100)	$200,000 (1,100)	n/a
Subcontracts			
<u>Laboratory</u> PFAS targeted + TOP (PFAS grant) OPEs, Bisphenols, Kolodziej lab tire/vehicle chemicals (DCB)	 $27,521 $15,201	 $36,062 $23,646	Additional samples
Consultant to support stormwater CEC modeling	$0	$20,000	Added staff-like senior expert to support modeling work
Direct Costs			
Sampling Travel	$800	$1,300	Additional samples
Conference travel (PFAS grant)	$3,250	$3,250	n/a
Equipment, supplies, shipping	$15,120	$18,932	Additional samples

Permit fees	$7,200	$9,900	Additional samples
Total RMP funding request	**$300,000**	**$450,000**	Additional Tier 2 RMP funding

Budget Justification

SFEI Labor
Labor hours for SFEI staff to complete all project elements.

Data Technical Services
Standard RMP data management procedures will be used. Data for stormwater samples will be uploaded to CEDEN. These costs are anticipated to be funded by the Destination Clean Bay and PFAS Sources to Solutions grants.

Laboratory Costs
Laboratory costs are anticipated to be funded by the Destination Clean Bay and PFAS Sources to Solutions grants.

Other Direct Costs
Other direct costs are anticipated to include travel, shipping, potentially sampler testing related equipment, and other miscellaneous sampling-related equipment.

Permit fees for temporary installation of remote samplers are a new cost identified from the SFEI Mayfly pilot monitoring in water year 2024. The budget assumes permit fees averaging $600 per site are required for 50% of remote and large autosampler sampling events. (Manual sampling has typically required minor or no permit fees.)

Sampling travel includes sampling-associated driving costs. Conference travel is for a project-related presentation at a professional conference, such as the California Stormwater Quality Association (CASQA) conference.

We anticipate purchasing and building the remote samplers and any ISCO or vacuum samplers to be used for this project under the approved RMP 2024 Remote Sampler Purchase project.

Early Funds Release Request
If this project is approved, we request early release of funds for use in 2024 to support parallel projects and to initiate monitoring during the wet season.

Reporting

Reporting for Task 2 will include the SST and RMP presentations. Task 3 will include a technical report (draft and final). Reporting for both Task 5 and 6 will include update presentations to the ECWG and SPLWG, as well as presentations to and discussions with the SST. For Task 5, stormwater monitoring data will be uploaded to CEDEN. For Task 6, a summary (draft and final) of the final sampler design, with photos, will be prepared

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Special Study Proposal: Plastic Additives in Bay Water and Archived Sediment

Summary: Plastic additives are an extensive group of chemicals used in the production of plastics for a variety of consumer, commercial, and industrial applications. Many of the chemical classes that comprise plastic additives are ubiquitous in the environment. In addition, several of these compounds are known to be toxic and exhibit a variety of effects on humans and animals. The RMP has previously found organophosphate esters (OPEs) and bisphenols in wastewater, stormwater, Bay water, and sediment, and is continuing monitoring a key subset of these contaminants via Status and Trends. Further monitoring already approved for 2024 will examine both of these classes along with multiple other plastic additive classes in wastewater.

To build on these efforts, we propose a study to assess the concentrations of plastic additives in Bay water and (optionally) archived sediment to inform our understanding of the fate and effects of these contaminants in the Bay. Data developed as part of this proposed study would result in addition of multiple new plastic additive chemicals and classes to the RMP tiered risk-based framework for emerging contaminants.

Estimated Cost:	Plastic Additives in Bay Water and Archived Sediment: $235,200 Plastic Additives ***Only*** in Bay Water: $172,940
Oversight Group:	ECWG
Proposed by:	Miguel Méndez, Rebecca Sutton (SFEI), Da Chen (Jinan/SIU)
Time Sensitive:	No

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop Sampling Plan (Ship Archived Sediment)	June 2025
Task 2. Field Sampling – Water (Dry Season)	Summer 2025
Task 3. Field Sampling – Water (Wet Season)	Fall 2025 to Spring 2026
Task 4. Laboratory Analysis	September 2026
Task 5. QA/QC & Data Management	December 2026
Task 6. Draft Report	March 2027
Task 7. Presentation at ECWG	April 2027
Task 8. Final Report	July 2027

Background

Plastic additives are an extensive group of chemicals that can include antioxidants, flame retardants, plasticizers, UV stabilizers, and several other compounds (Chen et al., 2021). Recent RMP studies resulted in classification of two classes of plastic additives, organophosphate esters (OPEs) and bisphenols, as High and Moderate Concerns for San Francisco Bay, respectively (Shimabuku et al., 2022). A high priority subset of compounds within each of these classes is now incorporated into ongoing Status and Trends monitoring activities.

However, the plastic additives included in ongoing RMP monitoring represent only a handful of the high production volume plastic additives in widespread use today. For example, a pro bono addition to the 2017 RMP monitoring of OPEs and bisphenols in Bay water included preliminary (pilot) characterization of 14 other plastic additives. All 14 were detected in the 2017 survey, with 5 of 14 analyzed found in greater than 50% of samples. One additive, tri(2-ethylhexyl) trimellitate (TOTM; also known as tris(2-ethylhexyl)benzene-1,2,4-tricarboxylate) exceeded its marine predicted no effect concentration (PNEC) of 6 ng/L at four sites, with a maximum concentration over an order of magnitude higher than its PNEC. Aquatic toxicity information as well as environmental occurrence data for many of these plastic compounds is limited.

Plastic additives enter the environment through multiple pathways from their substantial consumer and industrial uses, notably from wastewater and stormwater. Both OPEs and bisphenols have been observed in Bay Area wastewater and stormwater, often at comparable concentrations (Sutton et al., 2019; Mendez et al., 2022; Peter et al., submitted). Other plastic additives have not been previously measured in local wastewater or stormwater.

This proposal outlines a study to monitor a broad array of plastic additives in Bay water and archived sediment to continue building our understanding of the transport and fate of these contaminants to the Bay. This study will augment current efforts to monitor the same contaminants in wastewater in 2024, as well as recent monitoring of OPEs and bisphenols in stormwater to understand the relative influence of these pathways and their concentrations in the Bay. Further, these data can provide further insight into temporal or spatial trends in the Bay. The results from this study will support the categorization of numerous newly monitored plastic additives in the RMP's tiered risk-based framework.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to assess the concentrations of plastic additives in Bay water and archived sediment to improve our understanding of the fate of these contaminants in the Bay. The proposed study would provide data sufficient for risk screening for numerous contaminants not previously monitored in the Bay. Additionally, we will compare levels of plastic additives in different embayments to monitor potential regional spatial patterns of contamination, and in different seasons to provide insights as to the influence of wastewater and stormwater pathways. Evaluation of both water and sediment can provide information relevant to partitioning and fate in the Bay. For a subset of analytes, comparisons to concentrations measured in previous years will provide preliminary information on potential temporal trends.

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?	Characterize levels of plastic additives in Bay water and archived sediment	Risk screening will result in placement of multiple contaminants and classes in the tiered risk-based framework
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Characterize levels of plastic additives in Bay water during the wet and dry seasons	Seasonal differences in concentrations may be linked to the influence of wastewater vs. stormwater pathways
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?	Comparison of plastic additives concentrations in Bay water and archived sediment	Specific plastic additives are anticipated to be present in different environmental matrices due to partitioning behavior
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	Compare current concentrations to previously measured values	Preliminary information on temporal trends can be assessed for a subset of the contaminants in Bay water This study will provide baseline information that can be used to evaluate changes with time for other plastic additives
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A
6) What are the effects of management actions?	N/A	N/A

Approach

<u>Bay Water Sampling</u>
Collection of Bay water samples will be coordinated with the RMP S&T dry season water monitoring cruise in the summer of 2025 and wet season monitoring activities in water year 2026. All samples will be grab samples of Bay water (400 mL in 500 mL amber bottles), consistent with previous efforts. During the dry season water cruise, 13 of 22 sites will be sampled along with collection of a field duplicate and two field blanks. These samples will be targeted at specific sites where previous high detections of OPEs and bisphenols have occurred including wastewater and stormwater impacted areas in the South Bay.

During the wet season, all 16 field samples will be subject to monitoring for plastic additives. Wet season sampling includes two sets of samples collected at 4 near-field sites and 4 deep Bay stations. The 4 near-field sites will be sampled directly after a storm while the 4 deep Bay sites will be sampled within three weeks of the same storm. Overall, for this study, 19 wet season samples (including a duplicate and two field blanks) will be collected.

Dry and wet season monitoring (field samples and QA) will total 35 samples.

<u>Archived Sediment Sampling</u>
A subset of 15 sediment samples archived from 36 sites during the 2023 RMP S&T sediment cruise encompassing the deep Bay, near-field, and margins sites will be used for this study. These sites will be targeted to include areas in the Lower South Bay, where OPEs and bisphenols have been shown to be in greater concentrations in previous studies, as well as any areas that may have high concentrations based on current and past Bay water and wastewater effluent data.

<u>Analytical Methods</u>
Samples will be analyzed by Dr. Da Chen's laboratory (at Jinan University and Southern Illinois University), which previously analyzed bisphenols and OPEs in Bay water and wastewater, and will be analyzing plastic additives in wastewater in 2024. Dr. Chen's team will use their existing method, which uses a Shimadzu HPLC coupled to an AB Sciex 5500 Q Trap MS/MS (Toronto, Canada). This method can include analysis of up to 160 plastic additives (see Appendix, Table 3), including a suite of 24 OPEs, 16 bisphenols, 41 phthalates, 10 non-phthalate plasticizers, 40 antioxidants, and 29 UV stabilizers (Chen et al., 2021).

Budget

Table 2. Budget

Expense	Estimated Hours (Range)	Bay Water Only	Bay Water & Archived Sediment
Labor			
Study Design	35-45	$5,600	$7,200
Sample Collection	20-30	$3,000	$4,500
Data Technical Services		$33,000	$48,000
Analysis and Reporting	280-360	$45,000	$58,000
Subcontracts			
Dr. Da Chen, Jinan/SIU		$78,840	$109,500
Direct Costs			
Equipment		$1,000	$1,000
Travel		$2,000	$2,000
Shipping		$4,500	$5,000
Grand Total		**$172,940**	**$235,200**

<u>Budget Justification</u>

SFEI Labor
Labor hours are estimated for SFEI staff to manage the project, develop the study design, support sample collection (including shipment of archived samples), analyze data, review toxicological risks, present findings, and write a report including recommendations on future related monitoring. Data analysis can include examination of any preliminary temporal trends, spatial trends, comparison of observations across matrices, and investigation of linkages to potential pathways of importance to the Bay.

Due to the extensive list of analytes, analysis and reporting will require significant additional effort to fully assess the toxicological risks of these contaminants to the Bay.

Data and Technical Services
To minimize costs, data will undergo RMP QA/QC review and be formatted for CEDEN but not uploaded. Due to the extensive list of analytes, a broader budget has been provided to fully QA/QC all data.

Laboratory Costs (Dr. Da Chen, Jinan/SIU)
Analytical costs per sample are estimated at $2,190. Field samples collected for Bay water include 13 samples in the dry season and 16 samples in the wet season, with each effort including a field duplicate and two field blanks, resulting in a total analytical cost of $76,650. Additional analysis of 15 sediment samples is $32,850. For all analyses (50 samples), the total is $109,500.

Direct Costs
Equipment: An estimate of miscellaneous supplies associated with Bay water sampling.
Travel: An estimate of travel costs to present the study at a scientific conference.
Shipping: An estimate of shipping water and archived sediment samples from San Francisco, CA to Carbondale, IL.

Reporting

A draft report will be prepared by 03/31/27 and be reviewed by the ECWG and TRC. Findings will be presented at the spring ECWG meeting in 2027. Comments will be incorporated into the final report, published by 07/31/27.

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Appendix

Table 3. OPEs, bisphenols, and other plastic additives (Chen et al., 2021); specific analyte list may be refined as part of study design.

Group	Analyte	Full Name
Organophosphate Esters	BPA-BDPP	Bisphenol A bis(diphenylphosphate)
	BPDPP	t-butylphenyl diphenyl phosphate
	CDP	Cresyl diphenyl phosphate
	EHDPHP	2-Ethylhexyl-diphenyl phosphate
	IDDPP	Isodecyl diphenyl phosphate
	RDP	Resorcinol bis(diphenyl phosphate)
	T2IPPP	Tris(2-isopropylphenyl) phosphate
	T35DMPP	Tris(3,5-dimethylphenyl) phosphate
	TBOEP	Tris(2-butoxyethyl) phosphate
	TBP	Tributyl phosphate
	TCEP	Tris(2-chloroethyl) phosphate
	TCIPP	Tris(2-chloroisopropyl) phosphate
	TCrP	Tricresyl phosphate
	TDBPP	Tris(2,3-dibromopropyl) phosphate
	TDCIPP	Tris(1,3-dichloro-2-propyl) phosphate
	TEHP	Tris(2-ethylhexyl) phosphate
	TEP	Triethyl phosphate
	TPhP	Triphenyl phosphate
	TPrP	Tripropyl phosphate
	V6	Tetrakis(2-Chloroethyl)dichloroisopentyldiphosphate
Bisphenols	BPA	4,4'-(1-Methylethylidene) bisphenol
	BPAF	4,4'-(Hexafluoroisopropylidene) diphenol
	BPAP	4,4′-(1-Phenylethylidene) bisphenol
	BPB	4,4'-(1-Methylpropylidene) bisphenol
	BPBP	4,4'-(Diphenylmethylene) diphenol
	BPC	2,2-Bis(4-hydroxy-3-methylphenyl) propanone
	BPC-dichloride	4,4'-(2,2-Dichlorovinylidene)bisphenol
	BPE	4,4'-Ethylidenebisphenol
	BPF	4,4'-Methylenebisphenol
	BPG	4-[2-(4-hydroxy-3-propan-2-yl-phenyl)propan-2-yl]-2-propan-2-yl-phenol
	BPM	4,4′-(1,3-Phenylenediisopropylidene) bisphenol
	BPP	4,4'-[1,4-Phenylenebis(1-methylethane-1,1-diyl)] bisphenol
	BPPH	5,5'-Isopropylidenebis(2-hydroxybiphenyl)
	BPS	Bis(4-hydroxyphenyl) sulfone

Group	Analyte	Full Name
	BP-TMC	4,4'-(3,3,5-Trimethyl-1,1-cyclohexanediyl) bisphenol
	BPZ	4,4'-Cyclohexylidenbisphenol
Phthalates	BBzPh	Butylbenzyl phthalate
	iBCHPh	Isobutylcyclohexyl phthalate
	DAPh	Diallyl phthalate
	DBPh	Di-n-butyl phthalate
	DiBPh	Diisobutyl phthalate
	DiBzPh	Dibenzyl phthalate
	DiDPh	Diisodecyl phthalate
	DEPh	Diethyl phthalate
	DEHPh	Bis(2-ethylhexyl) phthalate
	BMPPh	Bis(4-methyl-2-pentyl) phthalate
	DHPh	Dihexyl phthalate
	DiHPh	Diisohexyl phthalate
	DNPh	Dinonyl phthalate
	DiNPh	Diisononyl phthalate
	DPePh	Di-n-pentyl phthalate
	DiPePh	Diisopentyl phthalate
	DPhPh	Diphenyl phthalate
	DPiPh	Diphenyl isophthalate
	DPrPh	Di-n-propyl phthalate
	DiPrPh	Diisopropyl phthalate
	DUPh	Diundecyl phthalate
Mono-phthalates	MBPh	Mono-n-butyl phthalate
	MiBPh	Monoisobutyl phthalate
	MBzPh	Monobenzyl phthalate
	MCHPh	Monocyclohexyl phthalate
	MEPh	Monoethyl phthalate
	MEHPh	Monoethylhexyl phthalate
	MHePh	Mono-2-heptyl phthalate
	MHxPh	Monohexyl phthalate
	MiNPh	Monoisononyl phthalate
	MOPh	Mono-n-octyl phthalate
	MPePh	Mono-n-pentyl phthalate
	MiPrPh	Monoisopropyl phthalate
	MEHHPh	Mono (2-ethyl-5-hydroxyhexyl) phthalate
	MEOHPh	Mono (2-ethyl-5-oxohexyl) phthalate

Group	Analyte	Full Name
	MCPPh	Mono (3-carboxypropyl) phthalate
Non-phthalate plasticizers	ATBC	Acetyl tri-n-butyl citrate
	DiBA	Diisobutyl adipate
	DBA	Dibutyl adipate
	DiDeA	Diisodecyl adipate
	DiDeAz	Diisodecyl azelate
	DEHA	Bis(2-ethylhexyl) adipate
	DHeNoA	Di(n-heptyl,n-nonyl) adipate
	DINCH	Di-isononylcyclohexane-1,2-dicarboxylate
	TCaT	Tricapryl trimellitate
	TOTM	Trioctyl trimellitate
UV stabilizers: benzothiazoles	2-Me-BTH	2-Methylbenzothiazole
	2-Mo-BTH	2-(Morpholinothio)-benzothiazole
	2-Me-S-BTH	2-(Methylthio)-benzothiazole
	2-OH-BTH	2-Hydroxybenzothiazole
UV stabilizers: benzotriazoles	1-H-BTR	1-Hydrogen-benzotriazole
	5-Cl-BTR	5-Chloro-benzotriazole
	5-Me-1-H-BTR	5-Methyl-1-hydrogenbenzotriazole
	1-OH-BTR	1-Hydroxybenzotriazole
	UV-234	2-(2H-benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol
	UV-320	2-(3,5-Di-tert-butyl-2-hydroxyphenyl) 2H-benzotriazole
	UV-326	2-Tert-butyl-6-(5-chloro-2H-benzotriazol-2-yl)-4-methylphenol
	UV-327	2,4-Di-tert-butyl-6-(5-chloro-2H-benzotriazol-2-yl)phenol
	UV-328	2-(2H-benzotriazol-2-yl)-4,6-di-tert-pentylphenol
	UV-350	2-(3-Sec-butyl-5-tert-butyl-2-hydroxyphenyl)benzotriazole
	UV-P	2-(2-Hydroxy-5-methylphenyl) benzotriazole
	UV-PS	2-(5-Tert-butyl-2-hydroxyphenyl) benzotriazole
UV stabilizers: benzophenone	BP1	2,4-Dihydroxybenzophenone
	BP3	2-Hydroxy-4-methoxybenzophenone
	BP4	2-Hydroxy-4-methoxybenzophenone-5-sulfonic acid hydrate
	BP6	2,2-Dihydroxy-4,4-dimethoxybenzophenone
	BP8	2,2′-Dihydroxy-4-methoxybenzophenone
	4-OH-BP	4-Hydroxybenzophenone
UV stabilizers: others	4-MBC	3-(4-Methylbenzylidene) camphor
	BMDM	4-Tert-Butyl-4′-methoxydibenzoylmethane
	IAMC	Isoamyl 4-methoxycinnamate
	OC	2-Ethylhexyl 2-cyano-3,3-diphenyl-2-propenoate

Group	Analyte	Full Name
	ODPABA	Octyl dimethyl-p-aminobenzoic acid
	OMC	Ethylhexyl methoxycinnamate
Antioxidants	BHA	2(3)-Tert-butyl-4-hydroxyanisole
	BHT-OH	2,6-Di-tert-butyl-4-(hydroxymethyl)phenol
	BHT-CHO	3,5-Di-tert-butyl-4-hydroxybenzaldehyde
	BHT-COOH	3,5-Di-tert-butyl-4-hydroxybenzoic acid
	3,5-DTBH	11-Methyldodecyl3-[4-hydroxy-3,5-bis(2-methyl-2-propanyl)pheny]propanoate
	4-tOP	4-(1,1,3,3-Tetra-methylbutyl)phenol
	AO245	hydroxy-3-methyl-5-(2-methyl-2-propanyl)phenyl]propanoate}
	AO259	1,6-Hexanediylbis{3-[4-hydroxy-3,5-bis(2-methyl-2-propanyl)phenyl]propanoate}
	AO425	2,2'-Methylenebis(4-ethyl-6-tert-butylphenol)
	AO565	4-[[4,6-Bis(octylsulfanyl)-1,3,5-triazin-2-yl]amino]-2,6-ditert-butylphenol
	AO697	(1,2-Dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl)bis{3-[4-hydroxy-3,5-bis(2-me thyl-2-propanyl)phenyl]propanoate}
	AO1035	Sulfanediyldi-2,1-ethanediylbis{3-[4-hydroxy-3,5-bis(2-methyl-2-propanyl)phenyl] propanoate}
	AO1081	2,2'-Thiobis(6-tert-butyl-p-cresol)
	AO1098	N,N'-1,6-Hexanediylbis{3-[4-hydroxy-3,5-bis(2-methyl-2-propanyl)phenyl]propan amide}
	AO1222	Diethyl 3,5-di-tert-butyl-4-hydroxybenzyl phosphonate
	AO2246	2,2'-Methylenebis(6-tert-butyl-4-methylphenol)
	AO3790	Tris(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)isocyanurate
	AO22E46	2,2'-(1,1-Ethanediyl)bis[4,6-bis(2-methyl-2-propanyl)phenol]
	AO44B25	4,4'-Butylidenebis(6-tert-butyl-m-cresol)
	AO-TBM6	4,4'-Thiobis(6-tert-butyl-m-cresol)
	diAMS	Bis[4-(2-phenyl-2-propyl)phenyl]amine
	DBHA	Dibenzylhydroxylamine
	DET	N,N'-diethylthiourea
	DTG	1,3-Di-o-tolylguanidine
	DPG	1,3-Diphenylguanidine
	DPT	1,3-Diphenyl-2-thiourea
	DPPD	N,N'-Diphenyl-1,4-benzenediamine
	PANA	N-Phenyl-1-naphthylamine
	BBOT	2,2'-(2,5-Thiophenediyl)-bis(5-tert-butylbenzoxazole)
	MMBI	Methyl-2-mercaptobenzimidazole

Special Study Proposal: Quaternary Ammonium Compounds (QACs) in Bay Water and Stormwater

Summary: Quaternary ammonium compounds (QACs) are surfactants widely used as antimicrobials and for other purposes in a variety of consumer products. The recent COVID-19 pandemic significantly increased use of products containing QACs, which had a likely impact on their release to the environment. Recent analysis of wastewater has found notable levels of QACs in influent, effluent, and biosolids with many of those commonly found in influent linked to disinfectant products. A smaller set of samples of sediment, Bay water, and stormwater have also exhibited the presence of QACs. Currently the limited number of measurements available result in classification of these contaminants as Possible Concern within the RMP tiered risk-based framework for emerging contaminants in the Bay.

We propose a study to assess the concentrations of at least 20 QACs in Bay water and (optionally) stormwater to understand the transport, fate, and effects of these contaminants in the Bay. Data developed as part of this proposed study would be sufficient for more definitive placement of QACs within the tiered risk-based framework.

Estimated Cost:	Monitor QACs in Bay Water and Stormwater: $164,000 Monitor QACs ***Only*** in Bay Water: $106,000
Oversight Group:	ECWG
Proposed by:	Miguel Méndez, Rebecca Sutton (SFEI), Bill Arnold (UMinn)
Time Sensitive:	No

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop Sampling Plan	June 2025
Task 2. Field Sampling: Water (Dry Season)	Summer 2025
Task 3. Field Sampling: Water (Wet Season) & Stormwater	Fall 2025 to Spring 2026
Task 4. Lab Analysis	September 2026
Task 5. QA/QC & Data Management	December 2026
Task 6. Presentation at ECWG	April 2027
Task 7. Draft Manuscript	June 2027
Task 8. Final Manuscript	August 2027

Background

Quaternary ammonium compounds, or QACs, are a major class of primarily cationic (positively charged) surfactants with important antimicrobial, anti-static, and surfactant properties. Because some QACs have major uses as antimicrobial active ingredients, recent increases in use occurred in response to COVID-19. Many of these compounds are designated as high production volume chemicals.

QACs are used in a wide swath of consumer, industrial, and medical products, which has led to considerable amounts ending up in wastewater. Research on the fate of QACs indicates effluents and biosolids from WWTPs as a major culprit in environmental contamination (Arnold et al., 2023; Clara et al., 2007; Li et al., 2014; Pati and Arnold, 2020). The unique cationic and hydrophobic properties of QACs lead to adsorption onto particles, particularly those with high organic matter content and/or minerals with negatively charged surfaces (Zhang et al., 2015). QACs are constructed to be biocidal and have been shown to be toxic to a variety of aquatic organisms including algae, invertebrates, fish, and microorganisms (Nałęcz-Jawecki et al., 2003; Sandbacka et al., 2000; Zhu et al., 2010).

The earliest study of QACs in San Francisco Bay focused on sediment, with several QACs found at sites across the Bay, especially the Lower South Bay where the influence of wastewater and stormwater are particularly strong compared to the rest of the Bay (Miller et al., 2020). A recent multiyear study focused primarily on QACs in wastewater, and found them in influent, effluent, and biosolids. Interestingly, QACs detected at the highest levels in influent were commonly used in disinfectant products, indicating these as a large source of PFAS to wastewater. Decreasing levels from influent to effluent indicate their effective removal.

However, the levels entering the Bay are still of concern, with six measurements in Bay water samples collected in 2021 showing levels similar to effluent concentrations. Though toxicity risk screening is limited, available thresholds indicate 90th percentile levels in Bay samples may pose a risk to aquatic wildlife. Analysis of stormwater at two Bay sites exhibited concentrations in line with effluent levels, though their QACs fingerprint was notably different.

This proposal outlines a study to examine QACs in Bay water and (optionally) stormwater to further elucidate transport, fate, and effects of these contaminants. This study will build on recent efforts to monitor these contaminants in wastewater while providing further baseline water data to fully determine their presence and potential impacts. These data can provide further insight into any temporal or spatial trends in Bay water, especially in the Lower South Bay. The results from this study will allow the categorization of QACs in the RMP’s tiered risk-based framework.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to assess QACs in Bay water and stormwater to improve our understanding of these contaminants into the Bay. Comparisons to limited data from previous years in Bay water will aid in this analysis. Levels in stormwater and wastewater pathways will also be compared to help identify the relative importance of these pathways to Bay contamination.

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?	Characterize levels of QACs in Bay water	Risk screening will result in placement of QACs in the tiered risk-based framework
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Characterize levels in Bay Area stormwater and compare concentrations and profiles to recent wastewater data Characterize Bay water levels of QACs during the wet and dry seasons	Comparison of stormwater concentrations and profiles with previously collected wastewater data may provide insights on sources and the relative influence of these pathways Seasonal differences in concentrations may be linked to the influence of wastewater vs. stormwater pathways
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	N/A
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	Compare current Bay water concentrations to previously measured values	Preliminary information on temporal trends can be assessed for a subset of the contaminants in Bay water This study will provide baseline information that can be used to evaluate changes with time for QACs
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A
6) What are the effects of management actions?	N/A	N/A

Approach

<u>Bay Water Sampling</u>
Collection of Bay water samples will be coordinated with the RMP S&T dry season water monitoring cruise in the summer of 2025 and wet season monitoring activities in water year 2026. All samples will be grab samples of Bay water (3 L in polycarbonate bottles), consistent with previous efforts.

During the dry season water cruise, all 22 sites will be sampled along with the collection of two duplicates and two field blanks.

Similarly, during the wet season, all 16 field samples will be subject to monitoring for QACs. Wet season sampling includes two sets of samples collected at 4 near-field sites and 4 deep Bay stations. The 4 near-field sites will be sampled directly after a storm while the 4 deep Bay sites will be sampled within three weeks of the same storm. Overall, 21 wet season samples (including two field replicates and three field blanks) will be collected.

Dry and wet season monitoring (field samples and QA) will total 47 samples.

<u>Stormwater Sampling</u>
Based on sampling efforts and available funding, there is an opportunity to analyze up to eight stormwater samples from multiple sites across the Bay. This proposal includes staff budgets to visit up to three sites of specific interest for QACs, and assumes leveraging other stormwater monitoring efforts for additional samples.

<u>Analytical Methods</u>
Samples will be analyzed by Dr. Bill Arnold at the University of Minnesota using a previously published method (Mahony et al., 2023). At least 20 analytes will be evaluated, which represent some of the important subgroups of QACs (Appendix, Table 3). The list can be expanded if information about additional compounds merits that new compounds be included. Briefly, samples will be spiked with three surrogate standards, extracted by methods specific to each matrix, cleaned up by solid-phase extraction (SPE), and then analyzed via liquid chromatography triple quadrupole mass spectrometry (LC/MS-MS). Concentrations in all samples are calculated via internal standard quantification. Limits of detection are provided in the Appendix.

Budget

Table 2. Budget

Expense	Estimated Hours (Range)	Bay Water Only	Bay Water & Stormwater
Labor			
Study Design	30-55	$5,000	$9,000
Sample Collection	30-200	$4,500	$32,000
Data Technical Services		$14,000	$23,000
Analysis and Reporting	120-160	$20,000	$26,000
Subcontracts			
University of Minnesota		$55,000	$65,000
Direct Costs			
Equipment		$1,000	$1,000
Travel		$2,000	$2,000
Shipping		$4,500	$6,000
Grand Total		**$106,000**	**$164,000**

<u>Budget Justification</u>

SFEI Labor
Labor hours are estimated for SFEI staff to manage the project, develop the study design, support sample collection, analyze data, review toxicological risks, present findings, and write a report including recommendations on future related monitoring. Costs for sample collection include SFEI staff assisting to collect samples, leveraging ongoing S&T sampling and stormwater sampling where possible.

Data and Technical Services
To minimize costs, data will undergo RMP QA/QC review and be formatted for CEDEN but not uploaded.

Laboratory Costs (Dr. William Arnold, University of Minnesota)
The contract with the laboratory would cover six months of staff time and supplies. Assuming a negotiated indirect rate of 10%, the total cost would range from $55,000 to $65,000, depending on scope.

Direct Costs
Equipment: An estimate of miscellaneous supplies associated with Bay water and stormwater sampling.
Travel: An estimate of travel costs to present the study at a scientific conference.
Shipping: An estimate of shipping water and stormwater samples from San Francisco, CA to Minneapolis, MN.

Reporting

Findings will be presented at the spring ECWG meeting in 2027. The analytical partner will lead preparation of a report in the form of a manuscript to be submitted to a peer reviewed journal; SFEI staff will assist with preparation. A draft manuscript will be reviewed by the ECWG and RMP leadership in June 2027, and a revised manuscript will be submitted to the journal in August 2027. In addition, a summary of the data, risk screening, and monitoring strategy for QACs will be included in a future CEC Strategy Update document.

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Appendix

Table 3. List of QACs Analytes.

Abbreviation	Target Compound	LOD (ng/L)*
C10-ATMAC	decyltrimethylammonium	0.02
C12-ATMAC	dodecyltrimethylammonium	0.2
C14-ATMAC	tetradecyltrimethylammonium	0.5
C16-ATMAC	hexadecyltrimethylammonium	0.2
C18-ATMAC	octadecyltrimethylammonium	1.0
C8-BAC	octyldimethylbenzyllammonium	0.02
C10-BAC	decyldimethylbenzylammonium	0.03
C12-BAC	dodecyldimethylbenzylammonium	0.6
C14-BAC	tetradecyldimethylbenzylammonium	0.8
C16-BAC	hexadecyldimethylbenzyllammonium	0.4
C18-BAC	octadecyldimethylbenzylammonium	0.4
C8-DADMAC	dioctyldimethylammonium	~1
C8/C10-DADMAC	dioctyldimethylammonium/didecyldimethylammonium	1.1
C10-DADMAC	didecyldimethylammonium	0.9
C12-DADMAC	didodecyldimethylammonium	0.4
C14-DADMAC	ditetradecyldimethylammonium	0.2
C16-DADMAC	dihexadecyldimethylammonium	0.6
C18-DADMAC	dioctadecyldimethylammonium	2.3
C12-ETBAC	dodecyldimethylethylbenzyllammonium	0.5
C14-ETBAC	tetradecyldimethylethylbenzyllammonium	0.9

*LODs are concentrations in the original sample after a 1000-fold concentration.

Special Study Proposal: Synthetic Dyes in Bay Sediment, Water, Wastewater, and Urban Stormwater Runoff

Summary: More than 10,000 dyes are available commercially worldwide, with over 1 million tons produced annually. Azo dyes account for >70% of the global industrial demand. In addition to their environmental release as part of industry waste, synthetic dyes may also be released to the environment via the use (e.g., laundering, drying, shedding) and disposal of apparel, textiles, and other products containing them. Brominated and chlorinated azo dyes are structurally diverse and therefore have diverse environmental fates and toxicities, but many are mutagenic, genotoxic, or carcinogenic. Recent nontarget analyses suggest that azo dyes are abundant in indoor dust. Previous nontarget analysis of Bay sediment indicated the presence of synthetic dyes in Bay sediment, but these methods were not quantitative. Additionally, the previous San Francisco Bay Microplastics Study showed that microplastic fibers, many of which are colored and could therefore contain and leach synthetic dyes, are the dominant form of microplastics observed in Bay matrices. This study would evaluate the presence of synthetic dyes in Bay sediment and water samples, as well as evaluate wastewater effluent and urban stormwater pathways samples using high-resolution mass spectrometry. Concentrations in Bay sediment and water would be compared to available toxicity thresholds to assign detected chemicals to a tier in the RMP's tiered risk-based framework for CECs and determine whether follow-up study is needed. This would be a novel and important study of the fate and transport of synthetic dyes in an urban estuary, and provide an important case study for other receiving water bodies receiving urban discharges.

Estimated Cost:	$170,600
Oversight Group:	ECWG
Proposed by:	Diana Lin, Ezra Miller, and Rebecca Sutton (SFEI), Nelson Vinueza (North Carolina State University)
Time Sensitive:	No

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop study design	February 2025
Task 2. Ship archive sediment samples	June 2025
Task 2. Sample collection - wastewater	June 2025
Task 2. Sample collection - Bay water	September 2025
Task 3. Analysis of wastewater, sediment, Bay water samples	December 2025
Task 4. Sample collection - urban stormwater	February 2026
Task 5. Complete laboratory analyses	March 2026
Task 7. Presentation of Preliminary Results at ECWG	April 2026
Task 6. Draft Report	July 2026
Task 8. Final Report	September 2026

Background

Today, synthetic dyes have largely replaced natural dyes in modern textile processes due to ease of use, lower costs, and wide range of potential chemical structures (Millbern et al., 2024). More than 10,000 dyes are used in textile manufacturing, and they can be classified based on their chemical properties, structures, and affinities for different textile materials. Synthetic dyes can have a broad range of functional groups that will affect their solubility in water and partitioning to water or sediment in the environment. Azo dyes, which are characterized by the presence of an azo chromophore (the main color component in the molecule, which absorbs light at a particular wavelength) account for >70% of the global industrial demand. These dyes are not only used in textiles, but also in lacquers and varnishes, printing inks, plastics, and to color cosmetics, waxes (e.g., candles), soaps, leather, and paper. In addition to their environmental release as part of industry waste, azo dyes may also be released to the environment via the use (e.g., laundering, drying, shedding) and disposal of apparel, textiles, and other products containing them. Brominated and chlorinated azo dyes are structurally diverse and therefore have diverse environmental fates and toxicities, but many are mutagenic, genotoxic, or carcinogenic. While U.S. manufacturers have phased out the use of a handful of azo dyes, even these chemicals can still be present in imported items.

Despite their potential risk to aquatic life, environmental monitoring of synthetic dyes remains relatively rare. However, studies have revealed brominated azo dyes to be the most commonly detected and abundant contaminant in indoor dust (Dhungana et al., 2019; Peng et al., 2016). Other studies have implicated halogenated azo dyes in the mutagenicity of urban river water and sediment samples (Alzain et al., 2023).

Nontarget analysis of Bay sediment has revealed the presence of multiple synthetic dyes, including the azo dye pigment yellow 97; the synthetic dyes malachite green, multiple Victoria blues, and ethyl violet; and the dye additive Michler's ketone (Ferguson et al., 2022; Miller et al., in preparation). However, synthetic dyes have not been previously quantitatively monitored in San Francisco Bay; monitoring is needed to assess whether and to what extent these contaminants are present in the Bay. Previous microplastic monitoring in the San Francisco Bay found microplastic fibers, which could come from synthetic textiles among other potential sources and be carriers of dyes, to be abundant in Bay water, sediment, wastewater effluent, and urban stormwater.

The goal of this study is to conduct a screening-level evaluation of the presence of synthetic dyes in Bay sediment and water samples, as well as wastewater effluent and urban stormwater pathways samples using high-resolution mass spectrometry. Concentrations in Bay sediment and water would be compared to available toxicity thresholds to assign detected chemicals to a tier in the RMP tiered risk-based framework for CECs and determine whether follow-up study is needed. This would be a novel and important study of the fate and transport of synthetic dyes in an urban estuary, and provide an important case study for other water bodies receiving urban discharges.

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?	Characterize levels of synthetic dyes in wastewater effluent, stormwater runoff, and Bay water and sediment. Compare dye occurrence data with available toxicity information in scientific literature.	Do concentrations of synthetic dyes in Bay water and/or sediment indicate potential concern in the Bay? Do any newly identified CECs merit follow-up targeted monitoring?
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Assess whether wastewater effluent and/or urban stormwater runoff discharge are important pathways for synthetic dyes to enter the Bay. Assess whether wastewater treatment processes impact what dyes are detectable in Bay wastewater effluent.	Do wastewater treatment processes (e.g., disinfection, advanced secondary filtration) impact what dyes are detectable in wastewater effluent?
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?	Compare synthetic dyes detected in pathways vs. Bay water and sediment.	Which dyes tend to partition to water or sediment in the Bay? Which dyes appear persistent in the Bay?
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	N/A	N/A
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A

6) What are the effects of management actions?	N/A	N/A

Approach

The primary goal of this study is to conduct a screening-level assessment of synthetic dyes in the Bay and evaluate where synthetic dyes should be classified within the RMP's tiered risk-based framework for emerging contaminants. This study would also conduct a screening-level assessment of synthetic dyes in wastewater effluent and urban stormwater runoff.

<u>Sample Collection</u>

Select archived sediment samples from 2023 RMP Status and Trends (S&T) deep Bay sampling, 2023 RMP S&T Near-Field sampling, and the 2023 Margin Special Study will be analyzed for synthetic dyes, so no additional resources are needed for the collection of sediment samples. Between 20–30 samples will be selected for analysis, and site selection will focus primarily on Lower South Bay and South Bay, as well as proximity to treated wastewater and urban stormwater runoff discharges. Two sets of field duplicates will also be included. The number of samples that will be analyzed will be determined during the study design phase led by SFEI.

Wastewater effluent will be collected from six POTWs. Between 15–30 wastewater effluent samples will be collected and analyzed. Field duplicates and field blanks will also be collected for QA/QC evaluations. Wastewater sample collection will be coordinated with participating POTWs. Wastewater effluent samples may be collected before and after effluent disinfection to evaluate the transformation of synthetic dyes through the disinfection process, which could impact detections. Sample volumes are anticipated to be ~1L. The number of samples that will be analyzed will be determined during the study design phase in consultation with selected POTW participants, and considering the treatment processes on site.

Ongoing S&T Bay water monitoring will be leveraged to collect Bay water samples for analysis. Minimal additional resources are thus needed for the collection of Bay water samples. Between 15–30 Bay water sample sites will be selected for analysis, with site selection focused primarily on Lower South Bay and South Bay, as well as proximity to treated wastewater and urban stormwater runoff discharges. Sample volumes are anticipated to be ~1L. The number of samples analyzed will be determined based on the S&T sampling sites and preliminary results from sediment and wastewater analyses.

Urban stormwater sample collection efforts from other stormwater studies will be leveraged to collect urban stormwater runoff samples for analysis. A minimum of 3 urban stormwater runoff samples (up to 10) will be included for analysis, with a focus on urban residential land uses if available. The number of samples analyzed will depend on the availability of stormwater sampling activities that can be leveraged for this study. Minimal additional resources are needed for collection of Bay urban stormwater samples. Sample volumes are anticipated to be ~1L.

<u>Analytical Approach</u>

Samples will be analyzed by Dr. Nelson Vinueza's laboratory (at North Carolina State University - Wilson College of Textiles). Dr. Nelson Vinueza's research focuses on enhancing analytical methods for extracting and characterizing synthetic dyes and applying mass spectrometry tools for forensics analysis. His research has been sponsored by several federal agencies (NIH, NIST, NSF, USGS) and companies (Cotton Incorporated, P&G). He has published more than 48 peer-reviewed publications and more than 85 posters and oral presentations.

Bay archived sediment and Bay wastewater samples will be analyzed first to inform study design for Bay water and urban stormwater runoff samples, as these samples will not be collected until the latter half of 2025.

Analyte Extraction. The extraction of synthetic dyes from water or sediment samples can be cumbersome due to the complexity of the matrix composition. Based on prior project experience, samples will likely be extracted using the QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) approach (Feng et al., 2020; Sui et al., 2020), which is based on a salting-out extraction with a solvent followed by a dispersive solid phase extraction (SPE). This method is very flexible and modifiable. Solids sample extraction can be performed with a minimum of 100 mg material. For liquid samples, extraction can be done for 5–10 mL samples, which can be sub-sampled or concentrated from a larger sample volume.

Mass Spectrometry. The majority of mass spectrometry (MS) experiments will be carried out using an Agilent 6520 Quadrupole-Time-of-Flight (QTOF) mass spectrometer (Agilent, Santa Clara, CA). This is a high-resolution mass spectrometer that will aid in the identification and structural elucidation of the different classes of dye due to the combination of its high sensitivity and high mass accuracy (within 5 ppm) for both precursor and fragment ions. This QTOF has four different ionization sources—electrospray ionization (ESI), atmospheric pressure chemical ionization (APCI), atmospheric pressure photoionization (APPI), and direct analysis in real-time (DART)—which can be used to enhance the characterization capabilities of the QTOF. In addition, the QTOF has the ability to perform tandem mass spectrometry (MS/MS), which is ideal for the structural elucidation of known and unknown molecules. MassHunterTM Work Station software is used for data acquisition and data processing.

Another instrument used for structural elucidation of dyes and their derivatives (degraded products) is a Velos Pro Linear Ion trap mass spectrometer (LTQ model) from ThermoFisher Scientific. Despite its lower resolving power compared to the QTOF (around 1000 versus 20,000), the LTQ mass spectrometer can perform more than one stage of ion fragmentation (MSn), making structure elucidation of unknown molecules easier to compared to a single fragmentation stage of the QTOF. In the LTQ, the product ions obtained after the first fragmentation (MS/MS) stage can be trapped in the quadrupole ion trap and be fragmented again, and selected fragments can be further trapped and fragmented to obtain structure information of unknown dyes. These sequences of events can give an unparalleled characterization of unknown degradation products.

Chromatography instrumentation. With ESI, APCI, and APPI ionization sources, the QTOF will be coupled with a high-pressure liquid chromatography (HPLC) Agilent 1260 Infinity system to get dye absorption data. Sample separation will be achieved using a Zorbax Eclipse Plus C_{18} (2.1×50 mm, 3.5 μm) column or InfinityLab Poroshell 120 Phenyl-Hexyl (2.1×100 mm, 2.7 μm) column at 40 ºC.

Data Interpretation

The study results will be synthesized to establish a baseline for synthetic dye concentrations in Bay sediment and water, as well as wastewater effluent and urban stormwater runoff. Concentrations in Bay sediment and water will be compared to available toxicity thresholds to assign detected chemicals to a tier in the RMP's tiered risk-based framework for CECs and determine whether follow-up study is needed.

Budget

Table 3. Budget

Expense	Estimated Hours	Budget
Labor		
Study Design	140	$27,600
Sample Collection	85	$12,500
Data Technical Service	260	$42,000
Analysis and Reporting	172	$32,200
Subcontracts		
North Carolina State University		$50,300
Direct Costs		
Supplies		$1,000
Shipping		$3,000
Open Access Publication		$2,000
Grand Total		**$170,600**

<u>Budget Justification</u>

SFEI Labor
<u>Study Design and Sample Collection</u>: Labor hours are estimated for SFEI staff to manage the project and develop the study design in consultation with participating POTWs. Additionally, SFEI staff will pick up wastewater effluent samples from participating POTWs and ship samples to North Carolina State University. An additional 25 hours are included to coordinate sample collection of Bay water and urban stormwater samples and to have samples shipped to Raleigh, NC.

<u>Data Technical Services</u>: Data services will include QA/QC review. Data will be formatted to CEDEN but not uploaded.

<u>Analysis and Reporting</u>: Labor hours are estimated for SFEI staff to conduct risk screening evaluation using RMP's risk tiered framework and to support North Carolina State University in the synthesis and interpretation of data and report writing.

Laboratory Costs (Dr. Vinueza, North Carolina State University)
Analytical costs are estimated for Dr. Vinueza and graduate students to lead the analytical portion of the study and to lead a draft manuscript. Budget needs include support for Dr. Vinueza and graduate students time, materials, and, and time on analytical instruments, and are based on an initial pilot study for approximately a year. Budget is based on a North Carolina State University 15% indirect cost rate. Additionally, Dr. Vinueza and his students will present results virtually at an ECWG meeting.

Direct Costs
<u>Equipment</u>: Budget is included to purchase sample containers.
<u>Shipping</u>: Budget is included to ship samples from SFEI to Raleigh, NC.
<u>Publication</u>**:** Budget is included to pay for open access for journal publication.

Reporting

A draft report will be in the form of a draft manuscript and be reviewed by the ECWG and TRC. Comments will be incorporated into the final report, which will be in the form of a draft manuscript ready for publication.

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Special Study Proposal: Nontarget Analysis of San Francisco Bay Fish (Year 2)

Summary: Contaminants in sport fish may have both human and wildlife health implications. The RMP has been monitoring selected contaminants in sport fish for many years but has never done any nontarget analysis of this matrix. This two-year study leverages 2024 Status and Trends sport fish monitoring to collect sport fish samples for nontarget analysis. Year 1, funded in 2024, included developing a sampling plan and sample collection. Year 2 will cover the laboratory and data analysis and reporting. This type of analysis will provide a means to identify unanticipated contaminants that may merit follow-up targeted monitoring. It will also allow comparison of San Francisco Bay fish nontarget analysis contaminant profiles with those of fish from other locations such as the Great Lakes. Anticipated study outcomes would include priorities and recommendations for future investigations of newly identified CECs of potential concern observed in sport fish.

Estimated Cost:	$76,000
Oversight Group:	ECWG
Proposed by:	Ezra Miller & Rebecca Sutton (SFEI), Bernard Crimmins (AEACS, Clarkson University)
Time Sensitive:	Yes, year 2 of a two-year project

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Work with S&T Sport Fish Strategy Team to develop sampling plan (funded)	Spring 2024
Task 2. Sample collection (funded)	Summer 2024
Task 3. Lab and data analysis	Spring 2025 – Spring 2026
Task 4. Presentation to ECWG and TRC	April 2026
Task 5. Draft manuscript	September 2026
Task 6. Final manuscript	December 2026

Background

Sport fish in San Francisco Bay are an important matrix in which to understand the contaminant profile, as they are consumed by both people, particularly in low-income and immigrant communities practicing subsistence fishing, as well as by apex predators like cormorants and harbor seals. The RMP began sport fish monitoring in 1997, and Status and Trends samples are collected every five years (most recently in 2019) during the summer season. Data collected through this monitoring program not only provide updates on the status and long-term trends of contaminants in Bay sport fish, but are also used to update human health consumption advisories and evaluate the effectiveness of regulatory and management efforts to reduce the impacts of contaminants of concern in the Bay (Buzby et al. 2019).

Status and Trends sport fish contaminant monitoring by the RMP is focused on a limited list of contaminants: mercury, polychlorinated biphenyls (PCBs), dioxins, selenium, polybrominated diphenyl ethers (PBDEs), and select per- and polyfluoroalkyl substances (PFAS). However, investigations of sport fish and other wildlife collected from other highly urbanized coastal sites indicate that these regularly monitored contaminants represent only a small fraction of the total number of bioaccumulative contaminants present in aquatic life. While the RMP has been monitoring sport fish for many years, to date there has never been any nontarget analysis of Bay sport fish.

Nontarget analysis, a key element of the RMP's CEC Strategy, can help to provide a measure of assurance that the RMP is not missing unexpected yet potentially harmful contaminants simply because of failures to predict their occurrence based on use or exposure prioritization criteria. This type of nontarget study can lay the foundation for future targeted CECs monitoring by helping to identify new potential contaminants of concern without *a priori* knowledge of their occurrence. The RMP has conducted successful nontarget analysis of nonpolar, fat-soluble compounds in bivalve tissue and seal blubber (Sutton and Kucklick 2015), and polar, more water-soluble compounds in Bay water and wastewater effluent (Sun et al. 2020; Overdahl et al. 2021), as well as in fire-impacted stormwater (Miller et al. 2021). Nontarget analysis of marine mammal tissues is also currently underway as part of a pilot study to inform the RMP's Status and Trends program design.

The proposed two-year study will employ a non-targeted analytical approach to examine samples of Bay sport fish to assess the contaminant profiles in the food chain and identify potential additional contaminants for future monitoring. Year one of the study, funded in 2024, included developing a sampling plan and sample collection. Year two (2025) will cover the laboratory and data analysis and reporting.

Results may indicate the presence of contaminants accumulating in Bay food chains that are not typically analyzed in targeted monitoring studies. Alternatively, should results reveal that most compounds of concern for wildlife and human health are already included in targeted monitoring, this study will help confirm that current Bay monitoring sufficiently captures priority contaminants.

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?	Screen CECs identified via nontarget analysis for potential toxicity concerns, future monitoring needs, and data gaps.	Do any newly identified CECs merit follow-up targeted monitoring?
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Evaluate chemical profiles for evidence of source types.	Do variations in site profiles suggest influence of any specific sources?
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?	Assess results of nontarget analysis for the presence of unanticipated transformation products.	Do the results of nontarget analysis indicate transformation of parent compounds into unanticipated contaminants with potential concerns for Bay wildlife or human health?
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	N/A	N/A
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A
6) What are the effects of management actions?	N/A	N/A

Approach

<u>Bay Fish Sampling</u>

Although the RMP S&T biota monitoring design was updated in 2022, the design for sport fish remains largely the same, with samples collected every five years. This project involves collection of additional fish samples in conjunction with the 2024 S&T sport fish monitoring, using an "opportunistic" sampling approach planned with the help of the sport fish S&T team. Twelve homogenized composite samples of shiner surfperch, of a minimum 40 g each (20 g per analysis), will be collected. Half of this mass will be collected in teflon-free plastic jars for PFAS NTA analysis, and half will be in glass jars with Teflon-lined lids for non-polar compound analysis.

Shiner surfperch is a core RMP sport fish species and is a good species for spatial comparisons because individuals have small home ranges. The RMP has found that shiner surfperch is an excellent indicator of spatial variation for other contaminants such as PCBs. The five existing core S&T stations that have always been sampled as part of S&T monitoring will continue to be monitored, including San Pablo Bay, Berkeley, Oakland, San Francisco Waterfront, and South Bay (may include Redwood Creek, Artesian Slough, and/or Coyote Creek) (Figure 1 green dots). This project samples both expected relatively less contaminated sites such as San Pablo Bay and Berkeley, as well as sites with expected higher contaminant loads such as San Leandro Bay and the South Bay. Shiner surfperch will also be collected from the Priority Margin Unit locations to track PCB trends (Figure 1 orange dots). Fish are collected using otter trawls.

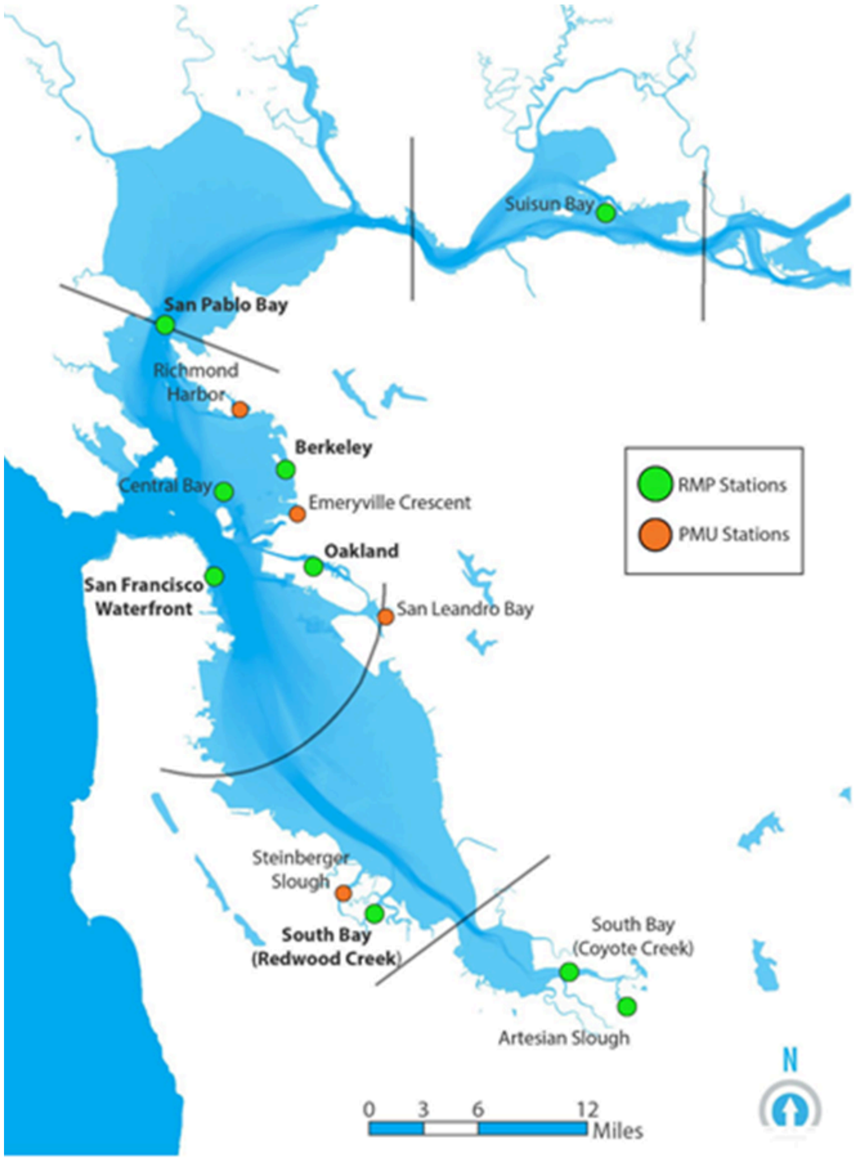

Figure 1. RMP S&T sport fish sampling locations. The green circles with bold names represent the five core stations included in the S&T Program (South Bay includes three locations – Redwood Creek, Artesian Slough, and Coyote Creek). Shiner surfperch will also be collected from the Priority Margin Unit locations to track PCB trends (orange circles).

<u>Analytical Methods</u>

This study will focus on shiner surfperch. Shiner surfperch are too small to be filleted, so they are processed whole but with head, tail, and viscera removed.

For nontarget screening (Crimmins lab; AEACS, Clarkson University), fish tissue samples will be processed and analyzed using two methods: one to look for non-polar compounds, and another to look for polar compounds, especially fluorinated polar compounds such as PFAS. In addition to nontarget analyses, ancillary data such as % lipid will be collected.

For non-polar compounds, dichloromethane (DCM) will be eluted through desiccated fish tissue homogenates followed by size exclusion chromatography for lipid removal (Fernando et al., 2018). Extracts will then be analyzed using a two-dimensional gas chromatography equipped with a high-resolution time of flight mass spectrometer (GC×GC-HRT, LECO) in accordance with Fernando et al. (2018) and Renaguli et al. (2020). The GC×GC resolves the extract mixture into 1000’s of individual components. The exact mass spectra of these components will be compared against a reference library containing over 500,000 chemicals to identify components in the tissues. Previously, this analysis has only been performed using electron impact ionization. The new system also has electron capture negative chemical ionization capabilities (ECNI). This mode selects for compounds that generate negative ions (halogenated components) and is traditionally used by low resolution instruments to quantify legacy halogenated chemicals (e.g., polybrominated diphenyl ethers). The new system is one of few available in the world that provides enhanced sensitivity of ECNI and 2-D chromatographic (GC×GC) and exact mass (30,000) resolution. The result will be a list of halogenated species for each tissue and concentration estimates using one or more representative reference standards. Compound identifications will be qualified by retention time, library matching, and spectral interpretation with exact mass accuracy (< 5 ppm).

Polar compound nontarget analysis will be performed in accordance with Crimmins et al. (2014) and Fakouri Baygi et al. (2021). Tissue homogenates will be extracted using methods described in Point et al. (2019) and then analyzed by ultra-high performance liquid chromatography-quadrupole time-of-flight mass spectrometry (UPLC-QToF) in electrospray ionization (ESI) mode. The instrument will be configured to operate in a data-independent MS/MS mode, alternating between low and high-energy channels to capture precursor and product ions for identification and confirmation of detected species. The data files will be analyzed using an algorithm developed in-house to screen for halogenated acids including polyfluorinated acids (Fakouri Baygi et al., 2016; Fakouri Baygi et al., 2021). The data reduction will consist of isolating species containing halogenated acid, ether, and sulfonate moieties.

The contaminant profiles for San Francisco Bay sport fish will be compared to profiles acquired previously from Great Lakes sport fish using the same sample preparation and analytical methods.

Budget

Table 2. Budget

Expense	Estimated Hours	Estimated Cost
Labor		
Study Design and Coordination	12	2,000
Data Technical Services	0	0
Analysis and Reporting	125	24,000
Subcontracts		
AEACS, LLC		50,000
Direct Costs		
Equipment		0
Shipping		0
Grand Total		**76,000**

<u>Budget Justification</u>

This proposal describes year two of a two-year study with a total budget of $99,000 (split between the two years). Year one ($23,000) covered study design, equipment, and shipping, while sample collection was covered via Status and Trends. Year two ($76,000) covers analysis and reporting.

SFEI Labor
Labor hours are estimated for SFEI staff to manage the project, develop the study design in collaboration with partners, support sample collection, analyze data, review toxicological risks, present findings, and assist with manuscript development.

Data Technical Services
Standard RMP data management procedures have not been developed for nontarget data. These data will not be uploaded to CEDEN.

Sample Collection
The estimated cost for collecting extra fish samples during the S&T collection efforts was $25,000, funded under the S&T fish monitoring budget. These extra fish samples can be archived if year two of this study is not funded for 2025.

Laboratory Costs
The Crimmins Laboratory (AEACS, Clarkson University) can provide nontarget analysis using two different methods on up to 12 fish tissues for a total cost of $50,000 (including 25% indirect rate). This budget includes both analysis and manuscript preparation. The analysis and reporting would take place during year 2 of the study.

Reporting

Results will be presented to the ECWG at the spring 2026 meeting, and may also be presented at a TRC meeting; a draft manuscript led by the Crimmins lab will serve as the RMP technical report for this project (draft for RMP review due September 2026, submission-ready draft[1] due December 2026).

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Special Study Proposal: Nontarget and Target Analysis of Fibers and Urban Stormwater

Summary: Synthetic apparel and textiles represent a large and growing source of chemical and microplastic fiber contamination globally. Microplastic fibers are the dominant form of microplastics observed in Bay matrices, and load estimates suggest urban stormwater runoff to be the dominant transport pathway. Fibers may pose ecotoxicity concerns linked to their physical form as well as to the leaching of harmful chemical additives and transformation products into aquatic ecosystems. Some chemical classes considered to be of High or Moderate Concern in the Bay according to the RMP's tiered risk-based framework are used as additives in synthetic textiles, including per- and polyfluoroalkyl substances (PFAS). These chemicals represent only a small fraction of textile-related chemical additives that may be transported to the Bay via fiber releases.

The RMP Emerging Contaminants and Microplastics Workgroups jointly propose to conduct nontarget analysis and target PFAS analysis on textile fibers and urban stormwater runoff to identify textile-related contaminants that have the potential to impact Bay water quality. This study would leverage an independent ongoing study led by SFEI to investigate whether tumble air-dryers are an important source of microplastic fibers to the Bay. Nontarget analysis can indicate the presence of plastic additives in fibers released to the environment, and statistical chemical fingerprinting techniques can be used to explore linkages between fibers and urban stormwater runoff. Observations may point to chemicals that have been overlooked in previous targeted monitoring in stormwater samples and merit quantitative analysis in the Bay or loading pathways.

Estimated Cost:	$123,700
Oversight Group:	ECWG and MPWG
Proposed by:	Diana Lin and Rebecca Sutton (SFEI), Roxana Sühring (Toronto Metropolitan University)
Time Sensitive:	Yes, to utilize sample collection and analysis from separate study

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop sampling plan	November 2024
Task 2. Stormwater sample collection	November - March 2024
Task 3. Lab analysis	June 2025
Task 4. Computational analysis and interpretation	September 2025
Task 5. Draft Report	March 2026
Task 6. Presentation at ECWG	April 2026
Task 7. Final Report	June 2026

Background

The San Francisco Bay Microplastic Study (Sutton et al., 2019) examined microplastic loadings from wastewater and urban stormwater pathways. Fibers accounted for approximately half of the microplastics observed in both the wastewater (55% fibers) and urban stormwater runoff pathway (39% fibers). Fibers in wastewater are likely to come from laundering textiles. SFEI is currently leading a two-year study (funded by California Sea Grant and California Ocean Protection Council) to investigate whether household tumble air-dryers may be a significant source of fibers to urban stormwater runoff (Dryer Study). The Dryer Study provides an opportunity to leverage sample collection efforts to collect microplastics from textiles from diverse households in the region. Despite the recognition that apparel and textiles may be a significant source of microplastic emissions to the environment (through laundering, drying, wear and abrasion), there has been limited attention to date on the release of chemical additives together with microplastic fiber emissions. This is an important data gap because many different additives are used in apparel and other textiles to improve their performance for different applications. Furthermore, additives used in textiles are often not chemically bound to the plastic polymer and therefore may be easily released from the microplastic fiber into the environment (Chen et al., 2022).

Many plastic additives can be used in substantial amounts in textile manufacturing (Chen et al., 2022). Some of these plastic additives have been observed in wastewater and urban stormwater runoff and environmental matrices. Researchers at Toronto Metropolitan University have developed a list of 124 plastic additives that are persistent, mobile, and toxic (PMT) and merit further monitoring. Prioritization criteria included registration for use in Canada, modeled high emissions from wastewater treatment plants (low removal), and high likelihood of being overlooked by regulations that focus on bioaccumulation potential (Fries et al., 2022).

The RMP is increasingly focused on urban stormwater runoff monitoring based on a growing body of evidence that this previously overlooked pathway is important not only for legacy contaminants but also for emerging contaminants and microplastics. However, Bay Area stormwater has not yet been characterized via nontarget analysis. Nontarget analysis is an important component of the Contaminants of Emerging Concern Strategy to identify unanticipated contaminants that may have been overlooked in targeted monitoring.

This proposal will implement nontarget suspect screening analysis on Bay stormwater samples and microplastic fibers collected from households to screen for contaminants that may have been overlooked previously in RMP monitoring. The suspect screening approach compares analytical spectra from samples to a library of compounds with known spectra. The suspect screening list in this study will include 124 persistent, mobile, and toxic contaminants that have been prioritized and characterized by Toronto Metropolitan University. Additional chemicals may be added to the suspect screening list. The results from this study will inform coordination among the Emerging

Contaminants Workgroup, Microplastics Workgroup, and Sources Pathways, and Loadings Workgroup.

Study Objectives and Applicable RMP Management Questions

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

Management Question	Study Objective	Example Information Application
1) Which CECs have the potential to adversely impact beneficial uses in San Francisco Bay?	Screen CECs identified in urban stormwater runoff and microplastic fiber samples via nontarget analysis.	Do any newly identified CECs merit follow-up targeted monitoring?
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Screen CECs identified in microplastic fibers and urban stormwater runoff samples via nontarget analysis. Conduct time series leachate studies from microplastic fibers.	Do chemical fingerprints suggest influence of microplastic fibers on urban stormwater pathway? What CECs in microplastic fibers are most likely to mobilize in the urban stormwater runoff pathway?
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	N/A
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	N/A	N/A
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A
6) What are the effects of management actions?	Explore linkage between microplastic fibers and CECs observed in urban stormwater.	Can mitigation of microplastic fiber emissions also impact CEC loadings via stormwater to the Bay?

Approach

<u>Study Design</u>

The primary goal will be to conduct nontarget analysis on microplastic fibers collected from dryers and in urban stormwater runoff samples.

As part of the separate Dryer Study, in 2024 SFEI will be collecting microplastic fibers outside of household and laundromat building dryer vent exhaust in order to estimate emission rates from drying operations. SFEI anticipates collecting between 40-80 samples (depending on the number of identified sampling locations and samples collected at each location). Microplastics fiber composition analysis will be performed by the Desert Research Institute (DRI). Each sample will be sub-sampled, and fibers will be individually enumerated, dimensions and colors recorded, and composition will be determined via microscope enabled FTIR (μFTIR).

For this present study, we will use the remaining samples not used by DRI to composite up to 20 samples that will be shipped to Toronto Metropolitan University for analysis. Samples may be composited based on the dominant polymer in each sample—e.g. compositing samples that are predominantly cotton or polyester.

Stormwater sample collection will seek to leverage and coordinate with other related studies to collect urban stormwater samples, in order to collect urban stormwater samples from more watershed to be included in this study. We will target sampling stormwater events at 3–8 watershed locations, and the actual number of sampling locations will depend on whether there are other related studies that can be leveraged to support stormwater sample collection. If possible, sites will be selected based on greater proportion of urban land use in the watershed, with an emphasis on proximity to residential communities and reduced sample collection costs due to existing sample collection underway as part of other studies. There will be focus on capturing the first fall flush at sites if feasible, using established RMP storm size criteria. QA/QC samples collected will include at least one field duplicate and two field blanks.

<u>Analytical Methods</u>
Samples will be analyzed by Dr. Roxana Sühring's laboratory (Assistant Professor at Toronto Metropolitan University). Dr. Sühring's is an expert on the analysis of plastic additives. She is the principal investigator on a Government of Canada funded study to identify microplastic sources using environmental forensic fingerprinting techniques.

Briefly, up to 20 composite microplastics samples (0.2 g dryer lint) will be leached under full-spectrum UV irradiation using filtered lake water for 30 days. One mL samples will be collected at 4 time points (e.g., days 2, 7, 14, and 30) to determine the leaching kinetics for different persistent, mobile, and toxic (PMT) plastic additives. Leaching kinetics have been shown to be essential for distinguishing contaminants that are adsorbed onto the surface of plastics (i.e., representative of contaminants in the surrounding environment) from plastic additives that are present in the plastic (Fries and Sühring, 2023).

Stormwater samples will be spiked with an in-house isotope-labeled benchmark mix and analyzed for PMT plastic additives using a liquid-liquid extraction developed by Environment and Climate Change Canada and adapted at the Emerging Contaminants Lab (Sühring et al., 2020). In short, 500 mL of filtered water will be added to a pre-cleaned glass separation funnel and shaken vigorously with 10 mL dichloromethane (DCM). The DCM will be collected in a glass vial and the extraction repeated for a total of three times. The combined 30 mL extracts per sample will be evaporated under a gentle stream of nitrogen and reconstituted in acetonitrile for instrumental analysis. For PFAS, the filtered stormwater samples will be analyzed using the online-solid phase extraction (SPE) method integrated in the HPLC-QToF-MS (high pressure liquid chromatography coupled with quadrupole time-of-flight mass spectrometry).

Samples will be analyzed using a previously validated method for the analysis of persistent, mobile, and toxic (PMT) plastic additives via accelerated leaching followed by high-performance liquid chromatography coupled with time-of-flight mass spectrometry (HPLC-QToF-MS) (Fries and Sühring, 2023). The resulting high-resolution mass-spectrometry data will be analyzed for at least 124 PMT plastic additives (Fries et al., 2022) (Table 3).

In addition, an existing online-solid-phase extraction (SPE) in Dr. Sühring's lab will be adapted for the rapid quantitative analysis of 30 PFAS (Table 4) in selected leachate samples using HPLC-QToF-MS as well as suspect screening for an additional 137 PFAS. These methods enable the detection of a wide range of PMT plastic additives with minimal analyte losses as well as the highly selective and sensitive analysis of targeted PFAS (online-SPE) without the need for extensive sample preparation.

The nontarget and target data will be analyzed using a combination of univariate (Wilcoxon rank test) and multivariate (principal component analysis) statistical approaches to evaluate similarities and differences among samples. Unique chemical fingerprints can be explored to identify potential chemical source linkages between textile fibers and stormwater samples.

Budget

Table 2. Budget

Expense	Estimated Hours	Budget
Labor		
Study Design	95	$20,000
Sample Collection	96	$20,000
Data Management and QA	70	$22,000
Analysis and Reporting	160	$29,000
Subcontracts		
Toronto Metropolitan University		$38,000
Direct Costs		
Equipment		$1,000
Shipping		$4,000
Open Access Publication		$2,000
Grand Total		**$136,000**

Budget Justification

SFEI Labor
Study Design: Labor hours are estimated for SFEI staff to manage the project, develop the study design in coordination with other leveraged studies, including the Dryer Study and multiple stormwater sample collection efforts.

Sample Collection: Microplastic fibers will be collected separately through the Dryer Study. For stormwater samples, labor hours are estimated to fully staff 2 stormwater sample collection events/locations. We anticipate being able to leverage other related stormwater sampling collection efforts to collect samples from additional locations.

Data Management and QA: Note nontarget analysis will not go through standard RMP QA/QC procedures, which were developed for targeted analysis. Limited SFEI labor hours are included for the SFEI data management team to track and manage field sampling forms, laboratory data reporting, and provide consultation on QA/QC considerations. PFAS Target data will go through RMP QA/QC review but will not be uploaded to CEDEN.

Analysis and Reporting: Labor hours are estimated for SFEI staff to support Toronto Metropolitan University in synthesis and interpretation of data and support report writing. Additionally, SFEI staff will lead preliminary toxicological review using the CEC's tiered risk-based framework.

Subcontracts: Laboratory Costs (Dr. Roxana Sühring, Toronto Metropolitan University)
Analytical costs per sample are estimated at $200. Twenty microplastic fiber samples will be analyzed in duplicate, through leaching studies over 4 time points for a total of 160 microplastic fiber leachate samples (20 microplastic fiber samples x 2 duplicates x 4 timepoints = 160 analyses). Budget includes analysis of eight urban stormwater runoff samples, including one field duplicate and one field blank for a total of 10 samples. For the combined nontarget analysis of microplastic fiber and stormwater samples, analytical costs are estimated to be $34,000. An additional $2,000 is included to partially support a PhD student to lead the computational analysis for chemical fingerprinting.

Additionally, Dr. Roxana and her students will lead reporting and analysis, which will be provided as in-kind support.

Direct Costs
Equipment: Budget is included for miscellaneous supplies needed to collect stormwater samples, including sample bottles, tubing, solvents for cleaning equipment.
Shipping: Budget is included to ship stormwater samples from SFEI to Toronto, Canada; as well as shipping dryer samples from Reno, NV to Toronto, Canada.
Publication**:** Budget is included to pay for open access journal publication.

Reporting

A draft report will be in the form of a draft manuscript prepared by 3/31/26 to be reviewed by the ECWG and TRC. Comments will be incorporated into the final report, which will be in the form of a draft manuscript ready for publication.

References

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Table 3. Priority suspect screening list of 124 persistent, mobile, contaminants via HPLC-MS analyses. Specific analyte list may be refined as part of study design.

CAS	Name	Function(s)
68-22-4	(17α)-hydroxy-19-norpregn-4-en-20-yn-3-one	Other
156-60-5	(1E)-1,2-dichloroethene	Blowing Agent
98-82-8	(1-methylethyl)-benzene	Catalyst, Colorant, Crosslinking Agent, Filler, Intermediates, Lubricant, Other Processing Aids
131-57-7	(2-hydroxy-4-methoxyphenyl)phenyl-methanone	Antioxidant, Colorant, Filler, Light Stabilizer, Other Processing Aids
13676-54-5	1,1'-(methylenedi-4,1-phenylene)bis-1H-Pyrrole-2,5-dione	Crosslinking Agent, Intermediates, Other Processing Aids
162881-26-7	1,1'-(phenylphosphinylidene)bis[1-(2,4,6-trimethylphenyl)-methanone	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Other Processing Aids
920-66-1	1,1,1,3,3,3-hexafluoro-2-Propanol	Intermediates
107-46-0	1,1,1,3,3,3-hexamethyl-disiloxane	Colorant, Intermediates, Lubricant, Other Processing Aids
71-55-6	1,1,1-trichloroethane	Lubricant, Odor Agent, Other Processing Aids, Plasticizer, Solvent
1493-13-6	1,1,1-trifluoro-methanesulfonic acid	Other
127-18-4	1,1,2,2-tetrachloroethene	Colorant, Intermediates, Lubricant, Other Processing Aids, Solvent
79-00-5	1,1,2-trichloroethane	Intermediates
79-01-6	1,1,2-trichloroethene	Catalyst, Colorant, Intermediates, Light Stabilizer, Lubricant, Odor Agent, Other Processing Aids, Solvent
3006-86-8	1,1'-cyclohexylidenebis[2-(1,1-dimethylethyl)peroxide]	Antioxidant, Catalyst, Crosslinking Agent, Initiator, Other Processing Aids, Plasticizer

CAS	Name	Function(s)
75-35-4	1,1-dichloroethylene	Filler, Flame Retardant, Intermediates, Monomer, Odor Agent, Other Processing Aids
111-96-6	1,1'-oxybis[2-methoxy-ethane]	Lubricant, Other Processing Aids, Solvent
115-10-6	1,1'-oxybis-methane	Biocide, Blowing Agent, Colorant, Filler, Intermediates, Lubricant, Odor Agent, Other Processing Aids, Viscosity Modifier
67-68-5	1,1'-sulfinylbis-methane	Blowing Agent, Other Processing Aids, Solvent
119-64-2	1,2,3,4-tetrahydro-naphthalene	Colorant, Intermediates
87-61-6	1,2,3-trichlorobenzene	Other
96-18-4	1,2,3-trichloropropane	Colorant, Crosslinking Agent, Intermediates, Monomer, Other Processing Aids, Solvent
120-82-1	1,2,4-trichlorobenzene	Other
81-07-2	1,2-benzisothiazol-3(2H)-one 1,1-dioxide	Biocide, Colorant, Filler, Intermediates, Other Processing Aids
106-93-4	1,2-dibromoethane	Flame Retardant, Intermediates, Lubricant, Other Processing Aids
95-50-1	1,2-dichlorobenzene	Biocide, Colorant, Filler, Lubricant, Plasticizer, Solvent
107-06-2	1,2-dichloroethane	Intermediates, Monomer, Odor Agent, Other Processing Aids
78-87-5	1,2-dichloropropane	Other
83-32-9	1,2-dihydro-acenaphthylene	Biocide, Colorant, Intermediates
100-97-0	1,3,5,7-Tetraazatricyclo[3.3.1.13,7]decane	Colorant, Crosslinking Agent, Filler, Intermediates, Monomer, Other Processing Aids

CAS	Name	Function(s)
108-80-5	1,3,5-Triazine-2,4,6(1H,3H,5H)-trione	Biocide, Catalyst, Crosslinking Agent, Flame Retardant, Initiator, Intermediates, Light Stabilizer
108-78-1	1,3,5-Triazine-2,4,6-triamine	Colorant, Filler, Flame Retardant, Intermediates, Light Stabilizer, Monomer, Other Processing Aids, Plasticizer
108-67-8	1,3,5-trimethyl-benzene	Colorant, Crosslinking Agent, Filler, Lubricant, Other Processing Aids
13674-87-8	1,3-Dichloro-, 2,2',2''-phosphate 2-propanol	Flame Retardant, Plasticizer
541-73-1	1,3-dichlorobenzene	Other
280-57-9	1,4-Diazabicyclo[2.2.2]octane	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Other Processing Aids
123-91-1	1,4-dioxane	Colorant, Filler, Intermediates, Odor Agent, Other Processing Aids
479-27-6	1,8-Naphthalenediamine	Other
109-70-6	1-bromo-3-chloropropane	Intermediates
13674-84-5	1-Chloro-, 2,2',2''-phosphate 2-propanol	Blowing Agent, Colorant, Filler, Flame Retardant, Intermediates, Other Processing Aids, Plasticizer
100-00-5	1-chloro-4-nitrobenzene	Other
95-14-7	1H-Benzotriazole	Antioxidant, Biocide, Colorant, Filler, Light Stabilizer, Lubricant, Other Processing Aids
80-15-9	1-methyl-1-phenylethylhydroperoxide	Biocide, Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Lubricant, Monomer, Other Processing Aids
88-72-2	1-methyl-2-nitro-benzene	Other
99-99-0	1-methyl-4-nitro-benzene	Other

CAS	Name	Function(s)
482-89-3	2-(1,3-dihydro-3-oxo-2H-indol-2-ylidene)-1,2-dihydro-3H-indol-3-one	Colorant
88-85-7	2-(1-methylpropyl)-4,6-dinitrophenol	Plasticizer
2440-22-4	2-(2H-benzotriazol-2-yl)-4-methyl-phenol	Antioxidant, Colorant, Filler, Intermediates, Light Stabilizer, Other Processing Aids
13472-08-7	2,2'-(1,2-diazenediyl)bis[2-methyl-butanenitrile]	Catalyst, Colorant, Crosslinking Agent, Initiator, Monomer, Other Processing Aids
78-67-1	2,2'-(1,2-diazenediyl)bis[2-methyl-propanenitrile]	Blowing Agent, Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Other Processing Aids
81-11-8	2,2'-(1,2-ethenediyl)bis[5-amino-benzenesulfonic acid]	Colorant
76-05-1	2,2,2-trifluoro-acetic acid	Other
22094-93-5	2,2'-[(2,2',5,5'-tetrachloro[1,1'-biphenyl]-4,4'-diyl)bis(2,1-diazenediyl)]bis[N-(2,4-dimethylphenyl)-3-oxo-butanamide]	Biocide, Colorant, Filler, Lubricant, Other Processing Aids
5468-75-7	2,2'-[(3,3'-dichloro[1,1'-biphenyl]-4,4'-diyl)bis(2,1-diazenediyl)]bis[N-(2-methylphenyl)-3-oxo-butanamide]	Biocide, Colorant, Filler, Lubricant, Other Processing Aids
5567-15-7	2,2'-[(3,3'-dichloro[1,1'-biphenyl]-4,4'-diyl)bis(2,1-diazenediyl)]bis[N-(4-chloro-2,5-dimethoxyphenyl)-3-oxo-butanamide]	Biocide, Colorant, Filler, Intermediates, Lubricant, Other Processing Aids
6358-37-8	2,2'-[(3,3'-dichloro[1,1'-biphenyl]-4,4'-diyl)bis(2,1-diazenediyl)]bis[N-(4-methylphenyl)-3-oxo-butanamide]	Colorant, Filler
3033-62-3	2,2'-oxybis[N,N-dimethyl-ethanamine]	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Other Processing Aids
108-20-3	2,2'-oxybis-propane	Other

CAS	Name	Function(s)
6674-22-2	2,3,4,6,7,8,9,10-octahydro-pyrimido [1,2-a]azepine	Colorant, Other Processing Aids
2554-06-5	2,4,6,8-tetraethenyl-2,4,6,8-tetramethyl-cyclotetrasiloxane	Colorant, Crosslinking Agent, Intermediates, Lubricant, Other Processing Aids
118-79-6	2,4,6-tribromophenol	Biocide, Flame Retardant, Intermediates, Other Processing Aids
126-86-3	2,4,7,9-tetramethyl-5-decyne-4,7-diol	Biocide, Colorant, Filler, Lubricant, Other Processing Aids
120-83-2	2,4-dichlorophenol	Other
584-84-9	2,4-diisocyanato-1-methyl-benzene	Blowing Agent, Catalyst, Colorant, Crosslinking Agent, Filler, Intermediates, Monomer, Other Processing Aids
87-62-7	2,6-dimethyl-benzenamine	Other
83016-70-0	2-[[2-[2-(dimethylamino)ethoxy]ethyl]methylamino]-ethanol	Colorant, Filler, Other Processing Aids
88-44-8	2-amino-5-methyl-benzenesulfonic acid	Colorant, Intermediates
78-51-3	2-butoxy-, 1,1',1"-phosphate ethanol	Colorant, Flame Retardant, Intermediates, Lubricant, Other Processing Aids, Plasticizer
115-96-8	2-Chloro-, 1,1',1"-phosphate ethanol	Flame Retardant, Intermediates, Odor Agent, Other Processing Aids, Plasticizer, Viscosity Modifier
1634-04-4	2-methoxy-2-methyl-propane	Other
71868-10-5	2-methyl-1-[4-(methylthio)phenyl]-2-(4-morpholinyl)-1-propanone	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Light Stabilizer, Other Processing Aids
15214-89-8	2-methyl-2-[(1-oxo-2-propen-1-yl)amino]-1-propanesulfonic acid	Intermediates, Monomer
110553-27-0	2-methyl-4,6-bis[(octylthio)methyl]-phenol	Antioxidant, Colorant, Heat Stabilizer, Light Stabilizer, Other Processing Aids

CAS	Name	Function(s)
88-19-7	2-methyl-benzenesulfonamide	Colorant, Intermediates, Plasticizer
79-46-9	2-nitropropane	Colorant, Intermediates, Other Processing Aids, Solvent
77-73-6	3a,4,7,7a-tetrahydro-4,7-methano-1H-indene	Colorant, Filler, Intermediates, Lubricant, Monomer, Other Processing Aids, Plasticizer
108-42-9	3-chloro-benzenamine	Other
1761-71-3	4,4'-methylenebis(cyclohexylamine)	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Monomer, Other Processing Aids
6864-37-5	4,4'-methylenebis[2-methyl-cyclohexanamine]	Colorant, Crosslinking Agent, Filler, Intermediates, Monomer, Other Processing Aids
101-77-9	4,4'-methylenebis-benzenamine	Antioxidant, Catalyst, Colorant, Crosslinking Agent, Initiator, Intermediates, Lubricant, Monomer, Other Processing Aids
80-51-3	4,4'-oxybis-, 1,1'-dihydrazide benzenesulfonic acid	Blowing Agent, Crosslinking Agent, Other Processing Aids
80-08-0	4,4'-sulfonylbis-benzenamine	Catalyst, Crosslinking Agent, Initiator, Intermediates, Monomer, Other Processing Aids
80-09-1	4,4'-sulfonylbis-phenol	Biocide, Colorant, Flame Retardant, Monomer, Other Processing Aids
121-57-3	4-amino-benzenesulfonic acid	Plasticizer
123-30-8	4-aminophenol	Other
100-40-3	4-ethenyl-cyclohexene	Flame Retardant, Intermediates, Odor Agent
100-43-6	4-ethenyl-pyridine	Other

CAS	Name	Function(s)
36888-99-0	5,5'-(1H-isoindole-1,3(2H)-diylidene)bis-2,4,6(1H,3H,5H)-pyrimidinetrione	Colorant
57-41-0	5,5-diphenyl-2,4-imidazolidinedione	Other
2855-13-2	5-amino-1,3,3-trimethyl-cyclohexanemethanamine	Antistatic Agent, Colorant, Crosslinking Agent, Filler, Intermediates, Lubricant, Monomer, Other Processing Aids
3380-34-5	5-chloro-2-(2,4-dichlorophenoxy)-phenol	Biocide, Colorant, Light Stabilizer, Odor Agent
1912-24-9	6-chloro-N2-ethyl-N4-(1-methylethyl)-1,3,5-triazine-2,4-diamine	Other
120-12-7	Anthracene	Antioxidant, Colorant, Plasticizer
95-16-9	Benzothiazole	Catalyst, Colorant, Crosslinking Agent, Initiator
80-43-3	Bis(1-methyl-1-phenylethyl) peroxide	Catalyst, Crosslinking Agent, Filler, Initiator, Intermediates, Lubricant, Other Processing Aids, Plasticizer, Viscosity Modifier
108-90-7	Chlorobenzene	Colorant, Crosslinking Agent, Filler, Intermediates, Other Processing Aids
75-00-3	Chloroethane	Other
75-01-4	Chloroethene	Colorant, Filler, Flame Retardant, Intermediates, Monomer, Other Processing Aids
74-87-3	Chloromethane	Blowing Agent, Colorant, Intermediates, Other Processing Aids
75-77-4	Chlorotrimethylsilane	Colorant, Intermediates, Other Processing Aids
107-66-4	Dibutyl ester phosphoric acid	Filler, Intermediates, Lubricant, Other Processing Aids

CAS	Name	Function(s)
75-71-8	Dichlorodifluoromethane	Other
119-61-9	Diphenyl-methanone	Antioxidant, Biocide, Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Light Stabilizer, Odor Agent, Other Processing Aids
85-42-7	Hexahydro-1,3-isobenzofurandione	Colorant, Crosslinking Agent, Intermediates, Lubricant, Monomer, Other Processing Aids
119-65-3	Isoquinoline	Other Processing Aids
330-54-1	N'-(3,4-dichlorophenyl)-N,N-dimethyl-urea	Biocide, Catalyst, Crosslinking Agent, Initiator, Other Processing Aids
103-90-2	N-(4-hydroxyphenyl)-acetamide	Intermediates, Monomer
97-74-5	N,N,N',N'-tetramethyl-thiodicarbonic diamide ([(H2N)C(S)]2S)	Catalyst, Crosslinking Agent, Initiator, Other Processing Aids
60-00-4	N,N'-1,2-ethanediylbis[N-(carboxymethyl)-glycine	Antioxidant, Biocide, Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Lubricant, Odor Agent, Other Processing Aids
97-39-2	N,N'-bis(2-methylphenyl)-guanidine	Crosslinking Agent
67-43-6	N,N-bis[2-[bis(carboxymethyl)amino]ethyl]-glycine	Biocide, Colorant, Filler, Intermediates, Lubricant, Odor Agent, Other Processing Aids
284-95-7, 2680-03-7	N,N-dimethyl-2-propenamide	Monomer, Other Processing Aids
102-06-7	N,N'-diphenyl-guanidine	Catalyst, Crosslinking Agent, Filler, Initiator, Light Stabilizer, Other Processing Aids, Plasticizer
102-08-9	N,N'-diphenyl-thiourea	Antioxidant, Catalyst, Crosslinking Agent, Initiator, Light Stabilizer

CAS	Name	Function(s)
5026-74-4	N-[4-(2-oxiranylmethoxy)phenyl]-N-(2-oxiranylmethyl)-2-oxiranemethanamine	Intermediates, Other Processing Aids
3030-47-5	N1-[2-(dimethylamino)ethyl]-N1,N2,N2-trimethyl-1,2-ethanediamine	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Other Processing Aids
91-20-3	Naphthalene	Biocide, Catalyst, Colorant, Filler, Light Stabilizer, Lubricant, Odor Agent, Other Processing Aids, Solvent
3622-84-2	N-butyl-benzenesulfonamide	Filler, Other Processing Aids, Plasticizer
461-58-5	N-cyanoguanidine	Catalyst, Colorant, Crosslinking Agent, Filler, Initiator, Intermediates, Other Processing Aids
3710-84-7	N-ethyl-N-hydroxy-ethanamine	Light Stabilizer
98-95-3	Nitrobenzene	Other
100-61-8	N-methyl-benzenamine	Colorant, Lubricant
56-23-5	Tetrachloromethane	Colorant, Other Processing Aids, Solvent
67-66-3	Trichloromethane	Colorant, Other Processing Aids
78-40-0	Triethyl ester phosphoric acid	Antioxidant, Colorant, Crosslinking Agent, Filler, Flame Retardant, Intermediates, Other Processing Aids, Plasticizer

Table 4: Quantitative analysis of 30 target PFAS using using HPLC-QToF-MS

PFAS name	Acronym
2,2-difluoropropanedioic Acid	DFPdA
Perfluorobutanoic acid (Heptafluorobutyric acid)	PFBA
Perfluoro-3-methoxypropanoic acid	PFMOPrA
Perfluorobutanesulfonic acid	PFBS
Perfluoro(2-ethoxyethane)sulfonate	PFEESA
Perfluoropentanoic acid	PFPeA
Perfluoro(4-methoxybutanoic) acid	PFMOBA
2,3,3,3-Tetra-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoic acid	HFPO-DA (Gen X)
Perfluoro-3,6-dioxaheptanoic acid	PFDHA
Perfluoro-1-pentanesulfonate	PFPeS
Perfluorohexanoic acid	PFHxA
4:2 Fluorotelomer sulfonic acid	4:2 FTS
Perfluorohexanesulfonamide	FHxSA
Perfluorohexanesulfonic acid	PFHxS
Perfluoroheptanoic acid	PFHpA
Perfluoro-1-heptanesulfonate;	PFHpS
Dodecafluoro-3H-4,8-dioxanonanoate	DONA
Perfluorooctanoic acid	PFOA
6:2 Fluorotelomer sulfonic acid	6:2 FTS
Perfluorooctanesulfonic acid	PFOS
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	9Cl-PF3OUdS
Perfluoro-1-(perfluoroethyl)cyclohexanesulfonic acid	PFECHS
Perfluorononanoic acid	PFNA
Perfluorononanesulfonic acid	L-PFNS
Perfluorodecanoic acid	PFDA
8:2 Fluorotelomer sulfonic acid	8:2 FTS
11-chloroeicosafluoro-3-oxaundecane-1-sulfonate;	11Cl-PF3OUdS
Perfluoroundecanoic acid	PFUnA
2-(N-Ethylperfluorooctanesulfonamido)acetic acid	N-EtFOSAA
Perfluorododecanoic acid	PFDoDA

Special Study Proposal: Stormwater In Vitro Toxicity Screening

Summary: Recent RMP studies have demonstrated the ubiquitous presence and complexity of CEC mixtures in Bay Area urban stormwater runoff. In vitro bioassay monitoring of environmental samples can detect possible biological effects that may not be predictable solely from targeted chemical analyses of the same samples or traditional individual chemical risk screening methods. The USEPA Center for Computational Toxicology and Exposure (CCTE) and EPA Region 10 are piloting using a rainbow trout gill cell high-throughput assay to detect toxicity of stormwater samples and compare between different locations. This is an imaging-based means of cell phenotype profiling with fluorescent dyes to quantify cellular-level changes in response to chemical exposure. This bioassay uses rainbow trout, which is both a common toxicity testing model and a Bay-relevant organism, to test for cytotoxicity and sub-cellular effects. We leveraged ongoing RMP stormwater sampling efforts during the water year 2024 wet season to collect a modest number of samples for pro bono extraction and analysis by CCTE. This project proposal covers Bay Area-specific data analysis and interpretation as well as coordination with EPA Region 10 and CCTE for data analysis and reporting. This project represents early implementation of an element of the RMP CEC strategy, namely strategic incorporation of novel toxicological methods to inform management.

Estimated Cost: $26,000
Oversight Group: ECWG
Proposed by: Ezra Miller (SFEI), Dan Villeneuve (USEPA)
Time Sensitive: Yes; leverages current EPA one-year project

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Sample collection and extraction	Winter 2024 (complete; pro bono)
Task 2. Coordination with EPA project	Spring 2024 – Fall 2025
Task 3. Lab and data analysis	Spring 2024 – Fall 2025
Task 4. Presentation to ECWG	April 2026

Background

Traditional chemical risk screening and prioritization methods generally rely on individual chemical occurrence and toxicity data. Traditional toxicity testing and threshold development methods rarely account for possible additive toxicity or interactions between chemicals (i.e., synergistic or antagonistic effects), except in the case of additive toxicity from multiple chemicals within a structural class with the same known mode of action (e.g., pyrethroids). However, chemicals may also influence one another's toxicity by affecting each other's uptake, metabolism, excretion, or toxicodynamics. This can modify the magnitude and sometimes also the nature of the toxic effect of a mixture compared to the effects of each individual chemical component of the mixture. Single substances present below their individual effect thresholds may thus still result in combined mixture effects (Kienzler et al., 2019; Silva et al., 2002).

Incorporation of in vitro bioassay monitoring approaches could support improved characterization of potential hazards to ecological receptors from the complex mixtures of CECs present in the Bay. Bioassay monitoring of environmental samples can detect possible biological effects that may not be predictable solely from chemical analyses of the same samples (Blackwell et al., 2019). Cell bioassays can complement traditional targeted chemical monitoring to screen for both known and unknown chemicals according to toxic mode of action. This screening can then be followed up with a more traditional assessment of individual contaminants and/or nontargeted chemical analysis to identify potential causative agents. This approach has been successfully used to prioritize sites for further monitoring in Southern California using endocrine-responsive and aryl hydrocarbon receptor cell assays (Mehinto et al., 2017, 2023). The Science Advisory Panel for CECs in California's Aquatic Ecosystems, convened at the request of the State Water Resources Control Board to provide unbiased science-based recommendations for monitoring strategies of CECs across the State, supports the use of bioassays as a way to provide additional information of value when screening for new substances in the environment that may have adverse bioactivity (Drewes et al., 2023). The RMP has a limited history of applying this type of bioassay monitoring. A pilot study testing six sites in the Lower South Bay of San Francisco Bay for estrogenic activity detected no activity in water and was less conclusive for sediment due to concerns about incomplete extraction of contaminants (Denslow et al., 2018).

Since the pilot study testing for estrogenic activity, the RMP has moved to focus its efforts not only on Bay monitoring but also on monitoring and modeling in contaminant pathways, especially wastewater effluent and urban stormwater runoff. Recent RMP studies have demonstrated the ubiquitous presence and complexity of CEC mixtures in Bay Area urban stormwater runoff (Peter et al., submitted). However, these types of expansive chemical assessments are costly and still likely provide only partial coverage of the full suite of contaminants present. For example, targeted analytical methods rarely capture the occurrence of transformation products, which in some cases can be more toxic than their parent CECs. Even when we have occurrence data for a compound, prioritization for monitoring and management is often hindered by a lack of toxicological data and, therefore, unknown or low-confidence toxicity thresholds. There is also the potential for difficult-to-predict mixture effects. Therefore, further exploration of in vitro screening of environmental samples is warranted. Following the Toxicology Strategy for CECs in the Bay (Miller et al., 2020), this approach should focus first on major pathways to the Bay (e.g., stormwater), as these waters will have a stronger signal due to their higher concentrations. The focus should also be on the most relevant molecular initiating events and corresponding endpoints for CECs; while estrogenicity is perhaps the most well-understood toxicity pathway due to its human health relevance, other modes of action such as neurotoxicity or teratogenicity may be more important for Bay contaminants and biota.

The Organisation for Economic Co-operation and Development test guideline 249 (OECD TG249) assay for cell viability testing in rainbow trout gill cells has an excellent correlation to in vivo survival data of rainbow trout, which is both a common toxicity testing model and a Bay-relevant organism. Scientists at the USEPA Center for Computational Toxicology and Exposure (CCTE) have developed an OECD TG249-inspired assay conducted in 384-well format that also allows for screening for more subtle (i.e., non-lethal) toxic effects. In the EPA assay, the OECD TG249 testing is paired with imaging-based high-throughput phenotypic profiling (HTPP, 'Cell Painting'; Nyffeler et al., 2021, 2023) conducted in parallel to obtain information about sub-cytotoxic bioactivity of chemicals. This method uses fluorescent dyes to visualize subcellular structures and to quantify cellular-level morphological changes in response to chemicals or other perturbations. Cell Painting is a high-throughput and cost-effective bioactivity screening method that detects effects associated with many different molecular mechanisms in an untargeted manner, enabling rapid in vitro hazard assessment. This new low cost, high-throughput test system can now be used to screen large libraries of chemicals for cytotoxicity and phenotypic effects on fish gill cells.

EPA Region 10 is currently piloting using this rainbow trout gill cell assay to detect toxicity of stormwater samples, compare stormwater toxicity between different locations, and prioritize locations for follow-up monitoring and management. Salmonids like rainbow trout are especially vulnerable to toxicity from the tire-derived contaminant 6PPD-quinone, which has been frequently detected in Bay Area stormwater (Peter et al., submitted). The toxicity of 6PPD-quinone and many other stormwater contaminants is still poorly understood, with only limited acute lethality data currently available, making a high-throughput bioassay especially valuable for predicting potential for adverse effects on aquatic biota. Because the assay is run in a 384-well plate format, there is plenty of room for extra samples, and EPA CCTE has generously offered to extract and analyze a small set of Bay Area stormwater samples for the RMP pro bono. The EPA project is a one-year project, in which Region 10 stormwater sampling is occurring summer 2024, with the bulk of laboratory and data analysis planned for Fall 2024 – Spring 2025.

We leveraged ongoing RMP and other SFEI stormwater sampling efforts during the water year 2024 wet season (January-February 2024) to collect a modest number of samples and sent these to CCTE for pro bono extraction and analysis. This project proposal covers Bay Area-specific data analysis and interpretation as well as coordination with EPA Region 10 and CCTE for data analysis and reporting.

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?	Screen Bay Area stormwater for potential toxicity concerns.	Can this type of in vitro toxicity testing capture toxicity concerns that may be missed by traditional chemical analysis?
2) What are the sources, pathways, loadings, and processes leading to the presence of individual CECs or groups of CECs in the Bay?	Compare available chemical profiles with toxicity data to inform CEC prioritization. Evaluate watershed characteristics in comparison with toxicity data to inform future monitoring design.	Does bioassay data correlate with chemical data? Do variations in site profiles suggest different toxicity profiles?
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	N/A
4) Have levels of individual CECs or groups of CECs changed over time in the Bay or pathways? What are potential drivers contributing to change?	N/A	N/A
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	N/A
6) What are the effects of management actions?	N/A	N/A

Approach

<u>Sample Collection</u>

We leveraged ongoing RMP and other SFEI stormwater sampling efforts during the water year 2024 wet season to collect both first flush grab samples and time-weighted composites across the hydrograph of each sampled storm at the sites described in Table 2.

Table 2. Sampled sites

Location	Type of Watershed	Storm Date(s)	Other Analytes
Pescadero Creek	large, rural	Jan 31	SSC only
Guadalupe Creek	medium, half-urban	Jan 31	PCBs, Hg, SSC
Walnut Creek	medium, half-urban	Jan 31	PCBs, Hg, SSC
Visitacion Valley	small, urban	Jan 31; Feb 18	Hg, SSC, total and dissolved metals, stormwater CECs

All samples were collected in amber glass bottles, kept on ice, and shipped to the CCTE lab for extraction within 96 hours of sampling.

<u>Laboratory Analysis</u>

Samples were extracted using Waters Oasis HLB solid phase extraction columns, eluted in methanol, evaporated to dryness, solubilized in dimethylsulfoxide (DMSO) at a 1000x concentration (relative to ambient), and kept frozen until analysis. For the Cell Painting Assay, rainbow trout gill cells are plated in 384-well format. One day after plating, media is exchanged, and the cells are treated with the sample extracts (diluted at least 300x). After 24 h of exposure, viability stains (alamar blue, CFDA-AM, neutral red) are applied and measured using a plate reader. Plates are labeled to visualize seven different cellular structures, followed by imaging and quantification.

Budget

Table 3. Budget

Expense	Estimated Hours	Estimated Cost
Labor		
Study Design, Coordination with EPA	45	8,000
Stormwater Sample Collection		0
Data Technical Services	0	0
Analysis and Reporting	95	18,000
Subcontracts		
n/a		0
Direct Costs		
Equipment		0
Shipping		0
Grand Total		**26,000**

Budget Justification

SFEI Labor

Labor hours are estimated for SFEI staff to manage the project, develop the data analysis design in collaboration with partners, analyze data, present findings, and assist with EPA report development as necessary.

Data Technical Services

Standard RMP data management procedures have not been developed for in vitro bioassays. These data will not be uploaded to CEDEN.

Sample Collection

Collection of stormwater samples has already occurred, leveraging sampling efforts for other stormwater projects.

Laboratory Costs

EPA is performing all sample extraction and rainbow trout gill cell assays pro bono.

Reporting

Results will be presented to the ECWG at the spring 2026 meeting, and may also be presented at a TRC meeting. Results and recommendations for future use of this assay will be incorporated into a future CEC Strategy Update.

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PFAS NMR Analysis in Wastewater, Stormwater, and Bay Matrices

Summary: Per- and polyfluoroalkyl substances (PFAS) are a class of thousands of fluorine-rich, chemically stable compounds widely used in consumer and industrial products. PFAS are ubiquitous in Bay matrices and considered a High Concern in the RMP tiered risk-based framework due to concentrations in Bay biota linked to potential human health risks. Most Bay studies to date have focused on targeted analytical methods analyzing up to 40 individual PFAS, which does not adequately capture the overall presence of PFAS in the environment. Preliminary application of broader methods (e.g., total oxidizable precursors [TOP] assay, adsorbable organofluorine [AOF] analysis) has illustrated the significant presence of unknown PFAS in Bay matrices. Each of these broader methods has its own limitations, and as yet no ideal standardized method exists to comprehensively characterize PFAS.

A new approach uses Fluorine-19 nuclear magnetic resonance (^{19}F NMR) spectroscopy to more broadly detect and quantify fluorine-containing compounds, including PFAS and other pollutants that contain fluorine.[1,2] This method not only provides an aggregated measure of organofluorine, it also provides information on the relative presence of different fluorinated functional groups, which provides insight as to the dominant types of PFAS and other fluorinated compounds present. We propose applying this new ^{19}F NMR method to wastewater and stormwater samples that will be undergoing analysis with multiple PFAS methods as part of RMP and USEPA-funded work. Complementary analysis using multiple analytical techniques will allow broader insights as to the utility of ^{19}F NMR. In addition, wastewater and stormwater samples are expected to have suitable concentrations for this analysis, which is less sensitive than targeted methods. In addition, limited analysis of available extracts of other Bay matrices (sediment, bird eggs, sport fish, marine mammals) is included. Overall, this proposed project would supplement current and future PFAS work to better characterize the presence, transport, and fate of fluorochemicals in the Bay.

Estimated Cost:	$385,000
Oversight Group:	ECWG
Proposed by:	Miguel Mendez, Diana Lin, Rebecca Sutton (SFEI), Bill Arnold (UMinn)
Time Sensitive:	Yes

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop Study and Sampling Plan	March 2025
Task 2. Ship Available Extracts (EPA 1633) & Archived Samples	May 2025
Task 3. Laboratory Analysis (Bay Matrices)	October 2025
Task 4. Field Sampling - Stormwater	Fall-Spring 2026
Task 5. Field Sampling - Wastewater	Spring-Summer 2026
Task 6. Ship Available Sample Extracts (EPA 1633; WW & SW)	Summer-Fall 2026
Task 7. Laboratory Analysis (WW & SW)	December 2026
Task 8. Presentation to ECWG Meeting	April 2027
Task 9. Draft Manuscript	May 2027
Task 10. Final Manuscript for submission	June 2027

[1] Bhat, A. P.; Pomerantz, W. C. K.; Arnold, W. A. Finding Fluorine: Photoproduct Formation during the Photolysis of Fluorinated Pesticides. *Environ. Sci. Technol.* **2022**, *56* (17), 12336–12346. https://doi.org/10.1021/acs.est.2c04242.

[2] Bhat, A. P.; Pomerantz, W. C. K.; Arnold, W. A. Fluorinated Pharmaceutical and Pesticide Photolysis: Investigating Reactivity and Identifying Fluorinated Products by Combining Computational Chemistry,19F NMR, and Mass Spectrometry. *Environ. Sci. Technol.* **2024**, *58* (7), 3437–3448. https://doi.org/10.1021/acs.est.3c09341.

Tire Wear Emissions and Washoff Estimates Journal Paper

Summary: Tire wear is one of the top sources of microplastic releases to the environment. Tire wear also disperses tire-related chemicals into the environment. SFEI studies supported by the RMP and others have found tire wear particles and tire-related chemicals in San Francisco Bay and its small tributaries, which drain the Bay watershed's local urban areas. In 2023, RMP published a report *Tire Wear: Emissions Estimates and Market Insights to Inform Monitoring Design* estimating the total emissions of tire wear particles in the San Francisco Bay region and the state of California. The report used extrapolations from the limited available monitoring data from SFEI's one-time microplastic monitoring effort (Sutton et al., 2019) to estimate the potential scale of tire particle and chemical transport into Bay Area surface waters at about 2-16% of overall emissions. While this washoff fraction estimate is lower than the 15–50% used in published tire particle modeling studies, it is in the range that would be expected based on road particle washoff data (9%, Pitt et al., 2005). To our knowledge, this is the first quantitative comparison between microplastic emissions and loads in urban runoff.

Presentations on this report have garnered international interest. Sharing the information in the form of a scientific journal paper would make it more widely used and could improve study design and data interpretation by others, thus improving the information available to the RMP.

This proposal requests funding to turn the relevant portions of the report into a scientific paper for publication in a peer-reviewed journal. We propose to collaborate on the publication with Professor Barbara Beckingham (College of Charleston), who helped us with tire particle volume estimates supporting the washoff estimates.

Estimated Cost:	$15,000
Oversight Group:	ECWG and MPWG
Proposed by:	Kelly Moran and Rebecca Sutton (SFEI), Barbara Beckingham (College of Charleston)
Time Sensitive:	Yes, report was published in 2023

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Draft journal paper	Spring 2025
Task 2. Final journal paper	Fall 2025

References

Moran, Kelly; Gilbreath, Alica; Méndez, Miguel; Lin, Diana; Sutton, Rebecca. 2023. Tire Wear: Emissions Estimates and Market Insights to Inform Monitoring Design. SFEI Contribution #1109. San Francisco Estuary Institute, Richmond, CA.

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Sutton, R., Lin, D., Sedlak, M., Box, C., Gilbreath, A., Holleman, R., Miller, L., Wong, A., Munno, K., Zhu, X., & Rochman, C. (2019). *Understanding Microplastic Levels, Pathways, and Transport in the San Francisco Bay Region.* (SFEI Contribution No.950.)

Tire Rubber Marker Analysis for Tire Wear Particle Quantification

Summary: Tire Wear Particles (TWPs) may be the biggest source of microplastics to San Francisco Bay, and are also a source of tire-related contaminants.

Norwegian Institute for Water Research (NIVA) scientists have developed state of the art methods for quantifying tire wear particles[1,2]. Reference materials of tire samples are used to estimate TWP using estimated relationships between emissions of tire materials from different types of vehicles and tires with different marker content. While NIVA has developed a tire database for tires used in Norway, no such reference database has been published for California tires. And while the U.S. Tire Manufacturers Association (USTMA) and the Tire Industry Project (TIP) have provided reference material (https://www.ustires.org/cmtt), they have not provided information as to types of tires used, and therefore it is not possible to ascertain whether the material is representative of what is in use in California. Because tire rubber composition varies due to brand, car type, area weather, and intended use, creating a representative regional tire database is important for improving the accuracy of estimated tire wear concentrations in environmental samples.

This proposal would analyze tire tread rubber from a representative set of new tires for the San Francisco Bay region (approximately 30 tires, each analyzed in triplicate[3,4]). Representative samples would include tires commonly used by passenger vehicles, and light trucks/SUVs, which represent a cumulative 76% of cars driven in California[5]. NIVA will analyze samples using pyrolysis GC-MS to quantify various tire markers to develop a reference database for tire material based on SF Bay Area regional tire trends. Results will be publicly shared through a peer-reviewed manuscript led by NIVA and supported by SFEI. Results will also be integrated into future RMP and SFEI reports to more accurately quantify TWPs analyzed via pyrolysis GC-MS. Overall, developing a robust database is critical for quantifying tire wear particles in the region and state. The data from this study could be used to update measurements of tire wear particles in Bay stormwater runoff.

Estimated Cost:	$105,000
Oversight Group:	ECWG and MPWG
Proposed by:	Diana Lin, Kayli Paterson, Kelly Moran, Rebecca Sutton (SFEI), and Elisabeth Rødland (NIVA)
Time Sensitive:	Yes, to inform other tire quantification studies in the Bay and state

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop study design	March 2025
Task 2. Collect tire rubber samples	September 2025
Task 3. Laboratory Analysis	February 2026
Task 4. Data analysis, interpretation, and reporting	June 2026

[1] Composed of styrene butadiene rubber and butadiene rubber) using pyrolysis GC-MS to quantify the mass of 4 different marker combinations for comparison: M4 (benzene, methylstyrene, ethylstyrene, butadiene dimer), M3 (methylstyrene, ethylstyrene, butadiene dimer), 4-vinylcyclohexene (4-VCH) and butadienes (butadiene dimer, styrene butadiene dimer and styrene butadiene trimer.
[2] Rodland et al., 2022. https://www.sciencedirect.com/science/article/pii/S0304389421020604
[3] Popular brands and models include Michelin Defender2, Yokohama YK-GXT, and Goodyear Eagle LS2
[4] Jefferson, A. 2023. *Tire Market: Top Brands & Retailers in 2023*. Traqline.com.
[5] Moran et al., 2023. SFEI Technical Report #109. Richmond, CA

PFAS Analysis Add-on to Stormwater Depth Monitoring Pilot

Summary: The RMP has funded a special study to pilot stormwater sampling approaches for microplastics. This funded MPWG pilot study will collect urban stormwater samples in two locations during a storm event. Simultaneous samples will be collected at 3 different depths (surface, mid-depth, near-bottom) in the deepest part of the channel to test the hypothesis that the channel is sufficiently well-mixed to reasonably conduct single-depth sampling in most Bay Area channels. Single-depth sampling is often used in RMP stormwater monitoring for PCBs and emerging contaminants based on previous evaluations that suspended sediment is sufficiently well-mixed during storm events to justify this approach. The MPWG pilot study is conducting the first evaluation of this approach for microplastics.

The current proposed study would leverage funded stormwater sample collection efforts by collecting additional stormwater samples for per- and polyfluoroalkyl substances (PFAS) analysis to provide an initial dataset to evaluate whether single-depth stormwater sampling is supported by field measurements. Samples will be analyzed using Total Oxidizable Precursor assay (TOP method) and EPA Draft Method 1633 (Target method). PFAS are a broad class of fluorine-rich specialty chemicals that span a wide range of physico-chemical properties and come from many different potential sources. Some PFAS are likely to be more strongly associated with suspended sediment, while others may be more strongly associated with different microplastics. PFAS as a class are classified as High Concern within the RMP's tiered risk-based framework, and a priority for stormwater monitoring efforts. The RMP's stormwater monitoring program is also developing automated remote samplers that would likely be sampling at a single depth during the storm. Considering the RMP investments in PFAS stormwater monitoring, this would be a small pilot study to evaluate the representativeness of stormwater sampling approaches. Results will be reported with the report deliverable for the MPWG stormwater pilot study.

Estimated Cost: $55,000
Oversight Group: ECWG
Proposed by: Diana Lin (SFEI)
Time Sensitive: Yes

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Collect PFAS stormwater samples	March 2025
Task 2. Laboratory Analysis	August 2025
Task 3. Data management and QA/QC	December 2025
Task 3. Data analysis and reporting	February 2025

Analysis of PFAS Wet Deposition Pathway (Rainwater)

Summary: Per- and polyfluoroalkyl substances (PFAS) are a class of thousands of fluorine-rich, chemically stable compounds widely used in consumer and industrial products. PFAS are ubiquitous in Bay matrices and considered a High Concern in the RMP tiered risk-based framework due to concentrations in Bay biota linked to potential human health risks. Recent stormwater analysis has highlighted its importance as a pathway for PFAS to the Bay with levels of individual PFAS similar to those found in wastewater. Wet deposition (i.e., rainwater) itself has been shown to contain PFAS at levels above US EPA drinking water health advisories, even in remote areas across the globe.[1] One study using non-targeted screening methods has also found concentrations of PFAS, especially ultra-short chain compounds, at low ng/L in rainwater away from point sources.[2] At present, we lack local data on PFAS in precipitation that would allow us to draw conclusions about the overall importance of this pathway relative to outdoor PFAS sources distributed within the surrounding watershed.

We propose investigating the presence of PFAS in rainwater in the Bay Area to establish baseline background data, elucidate its potential influence on stormwater concentrations, allow estimation of direct wet deposition to the Bay, and understand the community impacts of rainwater contamination. To evaluate a wide swath of the Bay Area, this study would incorporate citizen science to robustly monitor wet deposition including directly working together with SFEI staff and Bay communities (and their members) to establish 10 to 20 simple rainwater collection stations for use across three storms. Both targeted methods and total oxidizable precursor (TOP) assay will be used for PFAS analysis for comparison to stormwater with the potential to include additional methods such as analysis of ultra-short-chain PFAS. The study and sampling plan, including training and outreach materials, will be co-developed with participating community organizations with a budget for their engagement and sampling efforts. In addition to typical deliverables (i.e., report), this project would involve community outreach efforts to share the results such as a “town hall” style meeting presenting the results of the report and development of a concise fact sheet. Overall, this proposed project would supplement current and future PFAS work while building our efforts to integrate and collaborate with local Bay communities on science that impacts us all.

Estimated Cost:	\$251,000-\$440,000
Oversight Group:	ECWG
Proposed by:	Miguel Mendez, Jennifer Doughtery, Martin Trinh, Don Yee, Diana Lin
Time Sensitive:	No

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Develop Study and Sampling Plan, Training and Outreach (co-developed with community organizations)	August 2025
Task 2. Field Sampling - Rainwater	Fall-Spring 2026
Task 3. Laboratory Analysis	June 2026
Task 4. QA/QC and Data Management	September 2026
Task 5. Draft Report and Community Outreach	December 2026
Task 6. Final Report and Community Outreach	March 2027
Task 7. Presentation to ECWG	April 2027

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[1] Cousins, I. T.; Johansson, J. H.; Salter, M. E.; Sha, B.; Scheringer, M. Outside the Safe Operating Space of a New Planetary Boundary for Per- and Polyfluoroalkyl Substances (PFAS). *Environ. Sci. Technol.* **2022**. https://doi.org/10.1021/acs.est.2c02765.

[2] Kim, Y.; Pike, K. A.; Gray, R.; Sprankle, J. W.; Faust, J. A.; Edmiston, P. L. Non-Targeted Identification and Semi-Quantitation of Emerging per- and Polyfluoroalkyl Substances (PFAS) in US Rainwater. *Environ. Sci.: Processes Impacts* **2023**, *25* (11), 1771–1787. https://doi.org/10.1039/D2EM00349J.