Contaminant monitoring in the Sacramento San Joaquin Delta to inform environmental management

Final Prospectus

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Purpose

The Delta Independent Science Board (Delta ISB) is proposing a review to assess current contaminant monitoring programs in the Delta with a focus on data collection, synthesis, interpretation, and emerging scientific methodology. The review will discuss aspects of the monitoring programs that are presently effective and aspects that would benefit from further consideration. Emphasis will be placed on how contaminant monitoring programs inform management and decision-making – or the structured processes involved in identifying, evaluating, and mitigating – contaminant sources and ecological risk to aquatic ecosystems. Relevant management and decision-making processes in this context can include those that rely on contaminant monitoring to inform regulatory compliance, adaptive management, risk assessments, and different types of pollution prevention efforts in the Delta. The review will further evaluate the potential of advanced toxicity testing and chemical-analytical methods to contribute to a better understanding of the impacts of contaminants on the Delta ecosystem.

Motivation

Thousands of contaminants, often in quantities meaningful to ecosystem processes and human health, enter Delta waterways primarily via urban and agricultural stormwater and irrigation runoff, industrial and municipal wastewater effluents, and atmospheric deposition. They include metals, pesticides, pharmaceuticals, industrial chemicals, tire-wear constituents, and microplastics. Many have been shown to pose ecological risks in aquatic and riparian environments. The sheer number of chemicals and the complexities of assessing and measuring their toxic effects in ecosystems present significant challenges for monitoring, ecological risk assessment, and management of chemicals.

Well-designed monitoring programs are vital for understanding the sources, distribution, and health and environmental risks of chemical contaminants. Equally important to monitoring data collection is the subsequent data synthesis and assessment. Such analyses are critical to identify and quantify risk and potential threats to the ecosystem health. These latter activities are essential components of developing effective management actions to minimize the impacts of contaminants on organisms in the Delta ecosystem.

In 2014, the Central Valley Water Board initiated the Delta Regional Monitoring Program (Delta RMP) with the primary goal of tracking and documenting the effectiveness of beneficial use[1] protection and restoration efforts through comprehensive monitoring of water quality constituents and their effects in the Delta. The Delta RMP is a big step in the right direction. The proposed review will examine the monitoring programs in terms of their temporal and spatial coverage for monitoring the multitude of chemical contaminants and their ecological effects in the Delta. Such contaminants continue to be a challenge to ensure adequate water quality for healthy ecosystems[2].

Two previous reviews by the Delta Independent Science Board (Delta ISB) examined how water quality monitoring could be improved to support various environmental goals. The first Delta ISB review, entitled Water Quality Science in the Sacramento – San Joaquin Delta: Chemical Contaminants and Nutrients, identified data and information needs for entities responsible for the management of contaminants and nutrients in the Delta (Delta ISB, 2018). That review, which was based on input from a broad range of interested parties, found that the Delta RMP was "insufficiently comprehensive in terms of the contaminants monitored, the temporal and spatial coverage of its measurements, and consideration of how contaminants affect ecosystem processes." It further concluded that it was unclear how contaminant data entered into management decision-making; that adaptive management was rarely built into monitoring programs; that the link between water supply and contaminants was rarely explored; and more resources were needed to support coordinated and integrated monitoring and science efforts. In addition, the review identified the need a) to assess the effects of contaminants on the Delta ecosystem through holistic studies that combine toxicity testing and chemical

[1] Beneficial uses are designated in the **Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary** by the California Water Boards and include: water supply for human activities such as drinking water, recreation, fishing, agriculture, industry, and navigation, groundwater recharge, as well as supporting preservation of aquatic habitats, and migration, spawning, reproduction and development of fish.
[2] The Delta Plan, established by the Delta Reform Act, defines a healthy Delta ecosystem as one characterized by diverse and biologically appropriate habitats and ecosystem processes, functional corridors for migratory species, and viable populations of native resident and migratory species.

analyses with fish and food-web monitoring and b) to pay increased attention to interactions among contaminants, as well as interactions between contaminants and other stressors.

The second Delta ISB review, entitled Review of the Monitoring Enterprise in the Sacramento – San Joaquin (Delta ISB, 2022), concluded that "mercury and methylmercury seem to be monitored extensively in the Delta, whereas other chemical contaminants receive considerably less attention for informing management decisions," and there was not enough information to identify sources, fates, and effects of contaminants on the Delta ecosystem. Public comments from the IEP Contaminants Project Team and a presentation by the Delta RMP to the Delta ISB suggest that significant progress has been made in response to earlier recommendations. The proposed review will examine changes made since those reviews, recognize what is working well, and identify additional opportunities to build upon.

Background

The Delta is designated as an impaired waterway under Section 303(d) of the US Clean Water Act, meaning that certain pollutants chronically or repeatedly exceed protective water quality standards. Current listings of Delta waterways[3] show impairments for metals (primarily mercury), insecticides (primarily dichlorodiphenyltrichloroethane (DDT), pyrethroids, and organophosphates), polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and toxicity[4] (California State Water Resources Control Board, 2015). Water quality standards for these chemicals are intended to protect diverse aquatic species.

General Challenges Facing Contaminant Assessment: Establishing a monitoring program capable of quantifying environmental risks of contaminants to ecosystems is challenging (Connon et al. 2019), even when resources are adequate. Monitoring only a few contaminants, as required by regulation, or toxicity tests with a relatively few model species due to practical considerations may be inadequate to protect aquatic ecosystems. In most programs, contaminant monitoring involves laboratory (chemical and/or toxicological) analyses of field-collected water, sediment, or tissue samples. Ecological risk is commonly assessed by comparing measured

[3] See 2024 California Integrated Report

[4] A water segment shall be placed on the section 303(d) list if the water segment exhibits statistically significant water or sediment toxicity. See: California STATE WATER RESOURCES CONTROL BOARD (2015), WATER QUALITY CONTROL POLICY FOR DEVELOPING CALIFORNIA'S CLEAN WATER ACT SECTION 303(d) LIST.

environmental concentrations of individual chemicals to their respective water quality thresholds, e.g. environmental quality standards or criteria (see EPA Website on Risk Assessment, EPA Water Quality Standards). This type of risk assessment is effective at identifying specific contaminants for regulatory purposes. How well that offers ecological protection to the ecosystem from the many other contaminants is uncertain. It is easy to miss chemicals of toxicological importance, either due to method limitations or because the list of chemicals analyzed is outdated. This approach to risk assessment does not directly address how the risk results relate to the responses of individuals and populations in nature. Standard laboratory toxicity tests that expose individuals to environmental samples from the system and measure their responses provide more comprehensive information on the toxicity of contaminant mixtures. The generality of these effect-based tests to other contaminants can be limited by the small number of species (e.g., water flea, fathead minnow, green algae) and endpoints (mortality, growth, reproduction, behavior) for which standard protocols exist.

Current regulatory-centered monitoring practices may therefore underestimate the ecological effects of contaminants (e.g. Brooks et al. 2011, Fong et al. 2016). In the environment, organisms are generally exposed to mixtures of contaminants along with other stressors, such as pathogens, hypoxia, temperature stress, or algal toxins. Exposure is often variable over time and localized, and toxic effects are largely species specific. While regulation is aimed at identifying the impacts of individual chemicals on organisms tested under laboratory conditions, effects of contaminants in nature beyond mortality often can occur as subtle or cryptic impairments such as altered behavior or suppressed immunity (sub-lethal effects), which require additional analyses to relate them to standard ecological endpoints such as growth and mortality. Moreover, contaminants may negatively affect the food web by disproportionally impacting sensitive groups (e.g., insects, crustaceans) with potential consequences for the productivity and carrying capacity of the ecological system (Delta ISB 2024).

Advanced and Emerging Tools: Advances in analytical methods have been made in detecting contaminants and their effects on the environment (e.g. Wernersson et al. 2014, Escher et al. 2014, Connon et al. 2019). Quantitative structure-activity relationship (QSAR) modeling and large-scale collaborative projects such as the US "Toxicity Testing in the 21st Century" (Tox21) strategy and the European Union's "ToxRisk" established to integrate new concepts for regulatory chemical safety assessment are designed to screen chemicals for their toxic effects potential. These efforts are primarily aimed at preventing toxic chemicals from entering the market.

Some of the tools, such as certain *in vitro* bioassays, applied in these projects are well suited for environmental monitoring (e.g., Koenemann et al. 2018, Kienle et al. 2019, Kienle et al. 2022), especially when combined with information gained through "Adverse Outcome Pathways" linking effects at the cellular level with whole organism toxicity.

Review Approach and Products

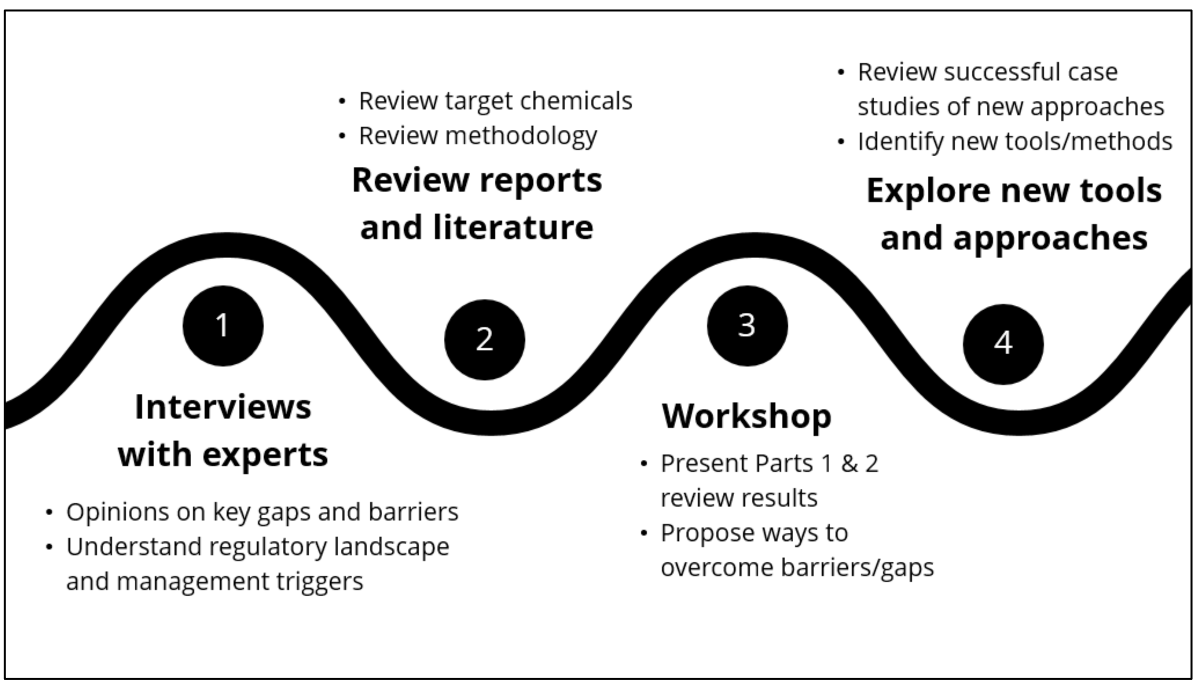
The overall goal of this review is to evaluate current contaminant monitoring programs in the Delta, and review how well the programs satisfy management needs with respect to occurrence and ecological risk of chemical contaminants.

This review will address management needs and several science actions outlined in the 2022-2026 Science Action Agenda (DSC, 2022). Specifically, the review will focus on Management Need 1 to improve coordination of data collection and evaluation of data needs across the Delta region and evaluate the individual and institution factors that "present barriers to coordination, learning, trusting, and using scientific information to inform decision-making and resource sharing within and among organizations." Additionally, it will address Management Need 2 to enhance monitoring integration in the Delta with a call to evaluate and update monitoring programs to ensure their ability to inform management decisions related to climate change impacts and emerging stressors.

The specific goals are to:

1. Assess current contaminant monitoring programs to determine the strengths and areas for improvement in how the data can provide the information needed by managers to make informed decisions regarding the ecological risk of contaminants.
2. Understand how monitoring informs decision making, i.e. how monitoring data are used in designing and taking management actions.
3. Review promising advanced and emerging methods and approaches that are candidates for advancing the current monitoring programs.

To achieve these goals, the review will be conducted in four parts. **Part 1** will consist of a series of interviews with experts involved in water quality regulation (e.g. Water Boards, EPA), contaminant monitoring, and risk assessment in the Delta (e.g. representatives of wastewater treatment facilities, agricultural water quality coalitions, Delta and SF Bay regional monitoring programs). The Delta ISB aims to gain an understanding of the regulatory landscape driving contaminant monitoring and the thresholds or triggers prompting management action. In addition, expert opinions will be obtained on approaches and design of current programs, how data are managed, synthesized and communicated, and on key gaps and barriers that may exist. In **Part 2**, we will review and evaluate current long-term contaminant monitoring programs in the Delta using relevant databases and documents on chemical pollutants (e.g. San Francisco Estuary Institute, 2023, Drewes et al. 2023, Fong et al. 2016) as well as available scientific information. Strengths and areas for improvement will be identified. For example, we may determine if chemicals identified as “bad players” elsewhere (e.g., Canada, European Union) are being monitored in the Delta, and if not, whether this should be considered going forward. Another potential approach is to compare available use data (e.g., from the pesticide use database of the Department of Pesticide Regulation) with chemicals being monitored. Information gathered during Parts 1 and 2 will then be analyzed and presented at a **Workshop (Part 3).** The workshop will be open to participation by all interested parties, and will be used to gather feedback and input on how the current monitoring could be leveraged and expanded to address the needs identified in Parts 1 and 2. **Part 4** will build on the Workshop with a focus on approaches to assess the environmental risk of chemical mixtures and multiple stressors, and on how advanced or emerging methods could be useful to identify the ecological risks of contaminants on the Delta ecosystem. This effort will be limited to well-established, preferably standardized, methods.



Scope of this review

Unlike the Delta ISB's 2018 Water Quality review, which was broad in scope, we will focus on chemical contaminant and toxicity monitoring in surface waters and sediments, and in point sources (e.g. wastewater treatment/industrial effluents, irrigation return water, stormwater outfalls) depending on data availability. Less focus will be placed on nutrients, HABs, and drinking water-associated contaminants as either significant work has already been or is being done on these topics, or they would warrant separate in-depth reviews. Nevertheless, we will discuss HABs and nutrients in the context of multiple stressors, and consider important contaminants solely monitored in drinking water monitoring programs where appropriate.

Importantly, this review will not generate new data on contaminants or their toxicity nor derive toxicity thresholds. Instead, we will rely on expert interviews, publicly accessible databases and available scientific literature to identify strengths and possible gaps in current Delta monitoring programs. The gaps in current Delta monitoring programs will be critical information needs in the context of assessing the ecological effects of contaminants in nature, the extent of which may be limited by the lack of toxicological data on a great number of chemicals and their metabolites and degradation products entering the Delta. We will therefore explore how advanced and emerging methods could be integrated into future Delta monitoring programs to address such challenges.

Intended Audience

Agencies and other parties who are conducting contaminant monitoring, are involved in creating legislation or regulations on contaminants, or are developing risk management plans, and the public.

Timeframe

The target date for finalizing the prospectus is the end of July 2025. Below is the timeframe for completing all phases of the review.

Key Task	Target Date
Finish prospectus	July 2025
Part 1: Conduct interviews to understand the regulatory landscape and approaches and design of current programs	Fall 2025-Spring 2026

Key Task	Target Date
Part 2: Assemble and evaluate information on current monitoring programs to determine if there are critical gaps	Fall 2025-Fall 2026
Part 3: Workshop	Winter 2026
Part 4: Research how advanced and emerging methods could be useful in addressing monitoring challenges.	Spring-Fall 2026
Release initial draft report for public comments	Summer 2027
Finalize report	Fall 2027/Winter 2028

Expected products and outcomes

The product of this review will be a formal Delta ISB Review document that describes the motivation, methods, and findings, and makes recommendations for future contaminant monitoring to assess ecological risks in the Delta. We will also create a short summary document that highlights key findings and recommendations.

The final report will include (i) a brief overview of the regulatory system driving contaminant monitoring and risk assessment in the Delta; (ii) a summary of the interviews with experts in the field identifying strengths and areas for improvement in existing programs; (iii) a review of existing contaminant monitoring programs in the Delta and identification of aspects being well assessed and potential critical needs and challenges; (iv) a summary of the Workshop; (v) a review of advanced and emerging effect-based and chemical-analytical methods capable of addressing the identified needs; and (vi) recommendations for future contaminant monitoring efforts and adaptive management of contaminants.

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