Watershed Modeling Workplan for 2027: Watershed Dynamic Model Enhancements and Applications

Summary

For 2026 to 2030, watershed modeling for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) is being funded by the Tracking Bay Health (TBH) grant from the USEPA. The RMP's Sources, Pathways, and Loadings Workgroup (SPLWG) and Technical Review Committee (TRC) will continue to play an important role in implementing and overseeing the RMP's watershed modeling program.

Since 2020, the RMP has been developing the Watershed Dynamic Model (WDM), a regional watershed and water quality model for the Bay. Recently, the RMP developed an *Integrated Watershed-Bay Modeling Strategy* (Heberger and McKee 2026), containing a multi-year plan for watershed modeling. A variety of model enhancements and applications were outlined to support priority management information needs. While the document laid out a vision and roadmap for watershed modeling, these are expected to be subjected to further review and refinement, as priorities continue to evolve. Therefore, we will adopt an "agile" or adaptive approach to project management. Here, we outline the proposed plan for completing watershed modeling tasks in 2027 in consultation with RMP stakeholders and advisors.

Under this proposed plan, the WDM will be used to provide updated regional-scale pollutant load estimates under various management scenarios at the Bay and Priority Margin Unit scales. Priority projects include continued model enhancements related to channel geometry and land use. We also plan to create a more refined watershed model to support analysis of Priority Margin Units such as San Leandro Bay. Because of the importance of sediment as both a resource and a delivery mechanism for pollutants, we will continue to refine modeling of erosion and sediment transport, particularly as it relates to grain size, and incorporate more local data.

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Estimated Project Cost $580k in 2027 ($2.5 million through 2030)

In 2027: $450k for SFEI labor, $115 for contractor(s), and $15K for direct expenses.

Oversight Group(s) SPL WG, PCB WG, Microplastics WG

Time Sensitive? Yes, particularly components related to PCB loading and control strategies, and providing inputs for the in-Bay hydrodynamic model.

Table 1. Study objectives and applicable management questions

Study Objective	Management Question
By updating meteorological forcing, land use data, and calculating urban/non-urban mass balances, this work directly addresses what the sources, pathways, and loadings of contaminants are to the Bay.	**SPL MQ3:** What are the management actions that could be implemented in the region to address pollutant pathways and sources, and where would they have the greatest benefit?
The "what-if" load reduction scenarios and PMU feasibility studies respond to questions regarding the effects of management actions on pollutant loads.	**SPL MQ3c**: What are the effects of management actions on loads from the most important sources, pathways, and processes?
Simulation of PMU-scale recovery and control measure feasibility addresses the rates of recovery for contaminated sites and the impact of focused management in these watersheds.	**PCB MQ1**: What are the rates of recovery of the Bay, its segments, and in-Bay contaminated sites from PCB contamination? **PCB MQ1A**: What would be the impact of focused management of PMU watersheds?
Enhancements to sediment modeling and the provision of boundary conditions respond to the need to quantify sediment fluxes and budgets for both sand and mud.	**SED MQ3**: What are the sources, sinks, pathways, and loadings of sediment and sediment-bound contaminants to and within the Bay and subembayments?
Exploring land use change and redevelopment scenarios addresses how watershed loads will shift in relation to environmental changes.	**SED MQ3.1:** How will watershed load to the Bay change in relation to changing climate, vegetation cover, and land use?

Background

To address complex water quality challenges in the Bay, the RMP has transitioned toward a coupled watershed modeling and monitoring approach designed to optimize efficiency and produce timely answers to critical management questions (McKee et al., 2025). Coupling a dynamic watershed model with an in-Bay model allows us to simulate how pollutants move from land surfaces and through the water and sediment of the Bay, ultimately accumulating in aquatic life (Heberger and McKee 2026; Jones et al., 2026). Since 2020, the RMP has worked to enhance watershed modeling capacity to provide: 1) information on pollutant concentrations and loads, and 2) reliable boundary conditions for in-Bay models.

A primary driver for this integrated approach is the need for science-based regulatory decisions, specifically concerning the scheduled updates for the Mercury (Hg) and Polychlorinated Biphenyls (PCBs) Total Maximum Daily Loads (TMDLs) in 2028 and 2030, respectively. For legacy pollutants like PCBs, which are highly localized due to historical industrial contamination, modeling is essential to explore the feasibility of load reductions at both local and regional scales. Furthermore, detailed modeling of Priority Margin Units (PMUs), such as San Leandro Bay and Redwood Creek, is required to explore rates of recovery in sediment and fish tissue, providing water quality managers with the information necessary to evaluate the effectiveness of remediation actions.

Accurate modeling of fine sediment transport from watersheds that drain to the Bay is a high priority, as many priority pollutants are predominantly sediment-bound. But watershed sediment modeling also directly supports marsh restoration and shoreline climate resilience efforts, also a priority for the RMP Sediment Workgroup and the Wetlands Regional Monitoring Program. By integrating watershed dynamic models with in-Bay sediment transport simulations, the RMP can also assess the impacts of climate change and sea level rise on the long-term health and resilience of the Baylands and mudflats.

Under the Tracking Bay Health (TBH) grant from the USEPA, the RMP has earmarked $2.5 million for watershed modeling through 2031. To be conservative, we are budgeting for labor and contracts through 2030, to allow extra time only if needed for producing contract deliverables. Table 2 summarizes planned expenses through 2030.

Table 2. Planned expenditures for watershed modeling, by category for 2027 to 2030, the duration of the EPA Tracking Bay Health grant.

Category	2027	2028	2029	2030	Total
SFEI Labor	450	479	510	543	1,982
Subcontracts	115	120	130	135	500
Comp. Hardware & Software	15	1	1	1	18
Total	**580**	**600**	**641**	**679**	**2,500**

Approach

Building upon foundational recalibrations of hydrology and sediment physics conducted in 2025 and 2026, the work to be completed in 2027 focuses on enhancing model precision, integrating modeling platforms, and applying these tools to address critical management questions for the Bay. The following sections outline our technical approach for the tasks scheduled for 2027.

Subcontracts - While much of the work will be completed in-house by SFEI staff scientists, we do not have the capacity to complete all of the proposed tasks described below. We plan to contract with a consultant with expertise in HSPF or LSPC[1] modeling and applications, specifically with respect to modeling the impacts of stormwater best management practice (BMPs) and green stormwater infrastructure (GSI) using models such as SWMM or SUSTAIN. SFEI is planning to issue a Request for Qualifications (RFQ) covering a variety of modeling disciplines, including watershed modeling, in the summer of 2026. Once contractor(s) are selected based on their qualifications, we will determine which tasks are appropriate to contract out. We have budgeted for $500,000 for subcontracts from 2027 to 2030, or $125,000 per year, or 20% of the total budget. This allows us to build up SFEI's capacity for watershed modeling, while bringing in outside help to provide technical assistance and for specialized modeling tasks.

[1] The WDM is an application of LSPC, the Loading Simulation Program in C++. This model, a descendant of the well-known HSPF model, has been widely used across the United States in many water quality investigations and TMDL analyses.

Investing in computational resources - The proposed 2027 budget includes the purchase of computer hardware and software, so that staff can efficiently run watershed models and visualize and interpret their output. This includes the purchase of three capable desktop computers and software subscriptions such as PyCharm, an integrated development environment for Python, and Zotero, a reference management system.

Table 3. Proposed watershed modeling tasks in 2027.

Task		Budget (x $1000)	
1. Model configuration and calibration			
	A. Update meteorological forcing datasets	50	
	B. Update channel geometry river reach F-tables	25	
	C. WDM/RWSM: Update and improve land use input data	60	
	D. Enhancements to sediment modeling	65	
			200
2. Watershed modeling applications			
	A. RWSM: Align HRUs with WDM and recalibrate RWSM	40	
	B. PCB TMDL Bay recovery: PMUs: Explore control measure feasibility through varied simulations by control measure type, scale, and pacing	100	
	C. Microplastics: Annual average discharge and load at the HRU scale	50	
	D. Provide boundary condition for in-Bay model: Daily flows by near-field subwatershed, three sediment size classes	50	
			240
3. Reporting and management			
	A. Reporting	85	
	B. Administration, stakeholder engagement, and project management	55	
			140
Total			**580**

1. Model configuration and calibration

To provide reliable inputs for sediment and pollutant transport, we will finalize the modernization of the WDM meteorological and hydraulic frameworks. This work is a continuation of work that was begun in 2026 and will allow us to go deeper and add more details to the model where there is a clear benefit to doing so.

A. Update meteorological forcing datasets

In 2026, we made important updates to the precipitation forcing data for the model, which resulted in improved model fit to observed discharges. Nevertheless, challenges remain due to the relatively sparse coverage of rain gages and the extreme spatial heterogeneity of rainfall in the Bay Area, where a distance of only 10 miles can result in a 20-inch difference in annual rainfall. This complexity is driven by the region's rugged topography and its position at the edge of the Pacific Ocean. Orographic effects are strong and there are a number of rain shadows, creating numerous distinct microclimates.

In 2027, we propose to contract with researchers at the University of Nebraska at Lincoln (UNL) to produce a new, state-of-the-art precipitation dataset for the Bay Area. Further, precipitation in the Bay Area is defined by extreme spatial heterogeneity. A separate proposal is attached, along with the CV for the principal investigator, Dr. Tirthankar Roy. Dr. Roy and PhD candidate Chitresh Anand have a strong background in precipitation science and have developed novel methods for imputation (or filling in of missing data) that will allow us to make greater use of local rain gage data. Deliverables include a new gridded hourly precipitation dataset over the Bay Area, and the code necessary to repeat the analysis, for example to extend the record with new observations. We will incorporate this new data into the model and anticipate that its increased spatial and temporal fidelity will increase our model's skill for predicting discharge, sediment, and pollutant concentrations.

B. Refine channel geometry F-Tables

This is also a continuation of work begun in 2026. Accurate channel hydraulics are essential for calculating the bed shear stresses that drive sediment scour and deposition. We will continue working to replace idealized trapezoidal channel cross-section representations with custom volume-outflow relationships (F-Tables) for critical reaches. This process involves collating locally measured cross-sections from SFEI and consultant field studies, HEC-RAS models from FEMA flood studies, and lidar-based topography. In 2027, we will also expand this effort to investigate the behaviors and operating rules of Bay Area reservoirs. There are currently 15 reservoirs represented in the model in a simplistic way. Improved simulation of reservoirs should help to improve model simulation in our large watersheds, including Alameda Creek, Coyote Creek, Guadalupe River, and select smaller ones (San Leandro Creek, San Lorenzo Creek, Novato Creek, and San Francisquito Creek). In 2027, we will further refine F-Tables and Reservoir representations to support improved model calibration.

C. Update and improve land use data

Accurate pollutant loading is highly dependent on the spatial distribution of human activities described by land cover and land use. We will conduct a quality assessment of the MTC 2020 land use dataset and begin making necessary refinements and/or seek an alternative land use/land cover (LU/LC) dataset for modeling. We may also investigate whether an update is needed to our estimates of directly connected impervious area (DCIA), which is used to partition land areas into either pervious or impervious categories. The distinction between pervious and impervious land areas is important for modeling, as the model uses different algorithms for predicting runoff and pollutant loading.

D. Enhancements to sediment modeling

The algorithms of the LSPC model are largely empirical: model parameters are set by tuning them to achieve the best fit between model predictions and observations. Calibration will prioritize optimizing the model for simulating urban stormwater flows and loads from Bay Area watersheds. Further along in the modeling work plan, there may also be scenarios where the model is optimized for other purposes.

During the recalibration of the model in the past year, we received many valuable suggestions from our advisors, internal colleagues, and stakeholders that we did not have time to implement. For example, we can and should expand beyond the current 17 USGS streamgages used for hydrology calibration, to include gages operated by local agencies such as water suppliers and flood control districts. In addition, future rounds of sediment recalibration can and should include several RMP monitoring stations where continuous turbidity-surrogate SSC observations are available. In 2027, selected additional higher priority data sets will be utilized.

This task also includes a subtask to redraw a number of the watershed model's subbasin boundaries. This is a continuation of work planned as part of the current 2026 workplan. Current work is focused on adding land area along the Bay shoreline that was previously excluded, and modifying the drainage basins around reservoirs to be consistent with standard modeling procedures. In 2027, we plan to add several new subwatershed boundary nodes to support the use of new calibration locations. In general, it is desirable for subbasins outlets to coincide with the location of monitoring stations. In the last two years, we have identified additional monitoring locations for both flow and sediment. As more calibration sites are added and uses for the model beyond Hg and PCBs are identified, there will be a continued need for refining the subwatershed structure. In 2027, we will strategically add model notes to support improved calibration.

We will refine the simulation of three sediment size classes: clay (≤0.03125 mm), silt (0.03125–0.0625 mm), and sand (>0.0625 mm). This involves incorporating local data from watershed reports and USGS particle size observations to ensure realistic Sediment Delivery Ratios (SDR) and in-stream transport dynamics.

By integrating these refined watershed outputs with advancing in-Bay models, SFEI will provide the science-based framework necessary for the 2030 PCB TMDL review, in-Bay modeling of sediment and contaminants.

2. Watershed modeling applications

These tasks directly support the upcoming TMDL updates and provide the boundary conditions necessary for in-Bay fate modeling.

A. RWSM and WDM Alignment

To ensure regional consistency, we will align the Hydrologic Response Units (HRUs) of the Regional Watershed Spreadsheet Model (RWSM) with those of the WDM. This allows the RWSM to leverage the WDM’s advanced rainfall-runoff calculations for annual average loading estimates, particularly for pollutants like microplastics (MPs) where monitoring data are sparse. Furthermore, this makes the outputs of the two models more readily intercomparable. In environmental modeling, it is often valuable to approach the same problem with different tools. In this case, using both a simple and a more sophisticated model to estimate pollutant loads will help us to “bookend” the results and provide an additional check on the results.

B. PMU Control Measure Feasibility: For Priority Margin Units (PMUs)

An important component of our 2027 workplan is the application of these models to evaluate specific regulatory and restoration strategies. We will use tools such as SWMM or SUSTAIN to explore how large-scale management actions—including Green Stormwater Infrastructure (GSI) implementation, urban redevelopment, and land use changes—impact Bay water quality. These models will forecast daily and annual load reductions under various climate and development futures that can be used as experimental “possible future scenario” boundary conditions for the in-Bay model to explore the likelihood of recovery.

We will simulate the pacing and scale of various control measures (e.g., source area soil removal, enhanced street sweeping) as boundary conditions for in-Bay model simulations to determine their impact on PCB recovery trajectories in sediment and fish tissue.

C. Microplastics modeling

We will calculate annual average flow volumes for specific HRUs to generate the first robust loading estimates for microplastics. This task provides the "order-of-magnitude" estimates needed to prioritize regional monitoring and source control efforts.

D. Provide boundary conditions for the In-Bay Model

The WDM output serves as the input for the in-Bay hydrodynamic and water quality model. We will work with the Bay modeling team to provide time series of flow, sediment, and pollutant concentration time series for near-field subwatersheds. These outputs serve as the critical boundary conditions for high-resolution Bay models, such as the San Leandro Bay (SLB) recovery simulations.

3. Reporting and management

A. Reporting

Planned deliverables include an annual watershed modeling report, presentations to the SPL Workgroup, and updates to the model website. The temporary online portal has been successful so far for sharing model outputs and data with stakeholders and advisors. In 2026, this will move to a permanent home on the SFEI website and continue to be updated and enhanced. Our goal is to make the WDM a community model, accessible to all, with all the files and documentation necessary for a quick start to watershed modeling. The online portal will need to be enhanced to address the goals that stakeholders endorsed in the *Integrated Watershed-Bay Modeling Strategy* (Heberger and McKee 2026).

B. Administration, stakeholder engagement, and project management

We plan to host quarterly model update meetings to present our latest findings to interested stakeholders and science advisors. Two such meetings have been held so far in 2026, and they have been a critical forum for technical staff to present draft results and receive feedback and input. These quarterly updates will help support our goal of making the RMP's watershed modeling transparent and scientifically defensible. Additionally, this task supports project management, the RFQ process, contracting, and management.

Table 4. Proposed deliverables and timeline

Deliverable	Due Date
1. Annual watershed modeling report	March 2028
2. Presentation to the SPL Workgroup	April 2028
3. Update to the WDM web page and model dashboard	May 2028

References

Heberger, M., & McKee, L. (2026). *Integrated Watershed-Bay Modeling Strategy* (Contribution No. 1224). San Francisco Estuary Institute. https://www.sfei.org/documents/integrated-watershed-bay-modeling-strategy

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