PCB Workgroup 2021 Proposal #3: Strategy for In-Bay Modeling of PCBs and Other Contaminants

Summary: This study would develop a strategy and multi-year workplan for modeling PCBs and other contaminants in the Bay. Modeling is needed to address several management questions that are a priority for PCBs, and a platform developed for PCBs could also be applied to answering management questions for other contaminants.

Proposed Funding: $45,050

Oversight group: PCB Workgroup

Proposed by: Craig Jones, Integral Consulting
Don Yee and Jay Davis, SFEI

Time Sensitive: Yes. Precursor to modeling work that would support revision or reevaluation of the PCBs TMDL.

Proposed Deliverables and Timeline

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Due Date</th>
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</thead>
<tbody>
<tr>
<td>Outline of draft strategy presented to PCBWG</td>
<td>Feb 2021</td>
</tr>
<tr>
<td>Draft technical report</td>
<td>Apr 2021</td>
</tr>
<tr>
<td>Final technical report</td>
<td>Jul 2021</td>
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</tbody>
</table>

Introduction and Background

PCB modeling is the foundation of the TMDL for PCBs in San Francisco Bay, which provides the framework for managing PCB impairment of Bay water quality. The TMDL is based on a simple one-box model of the long-term fate of PCBs in the Bay (Davis et al. 2007), coupled with a similarly general food web model for the Bay as a whole (Gobas and Arnot 2010). Together, these models provided estimates of the timeframe and magnitude of load reduction needed to bring PCB concentrations in key indicator fish species down to the target level of 10 ppb.

Additional modeling and conceptual model development have been performed since the TMDL models were developed.

- Multi-box model for the whole Bay – At the time the PCBs TMDL was nearing completion, SFEI developed a multi-box model for PCB fate (Oram and Davis 2008, Oram et al. 2008). This model defined the Bay as 50 laterally-averaged segments divided into two layers for a total of 100 boxes. In each segment, an upper box, encompassing the shallows, overlaid a bottom box extending to the deepest part of
the channel in each segment. The model built on salinity and sediment transport models developed by the USGS. Work on this model was abandoned in the late 2000s for several reasons, including: it was not going to be ready in time for the TMDL, there were unresolved problems in the underlying sediment model, the results were not substantially different from the results of the one-box model, and plans for more sophisticated modeling of nutrients were beginning to take shape.

- **Conceptual model of contaminant fate on the Bay margins** – In 2012, the RMP published a report presenting a conceptual model of contaminant fate for multiple contaminants on the Bay margins (Jones et al. 2012). Along with the conceptual model, the report presented a general strategy for modeling contaminants in the Bay margins. Key recommendations were:
  o use a single modeling physical transport modeling platform to address multiple contaminants;
  o conduct mechanistic modeling of physical transport in the margins and the Bay as a whole;
  o coordinate Bay modeling work;
  o develop an accessible repository for data from local studies; and
  o identify empirical data needed to support model development.

- **Priority margin unit conceptual model reports** – These reports (Davis et al. 2017, Yee et al. 2019, Yee et al. 2020) have presented conceptual models and simple mass budget models for three margin areas of management interest: Emeryville Crescent, San Leandro Bay, and Steinberger Slough/Redwood Creek. The mass budget models have provided first-order estimates of anticipated recovery rates under different loading scenarios and for different assumptions about input parameters. Extensive field data have also been collected in one of these areas (San Leandro Bay).

In PCB Workgroup discussions, stakeholders have identified several specific questions that are of current interest in the context of a possible revision of the PCBs TMDL and the 2030 deadline for stormwater agencies to achieve the load reduction goal stated in the original TMDL.

1. What would be the impact of focused management of PMU watersheds?
2. Should Bay segments be managed separately?
3. What would be the impact of in-Bay hotspot management at the segment scale?
4. Should the TMDL timeline be extended beyond 2030?

These questions call for studies that provide more robust estimates of fate in PMUs (#1), modeling of the whole Bay with a finer spatial resolution (#2 and #3), and either additional assessment with the whole Bay one-box model or a more robust whole Bay model (#4).

In addition to these needs for modeling PCBs, there are needs for modeling other contaminants. The RMP, in general, is shifting focus to studies that support management of contaminants of emerging concern. As recommended by Jones et al. (2012), a physical modeling platform should be developed that can address not just PCBs, but other contaminants as well.
Modeling plans are also being implemented or developed for other constituents and in other areas, including nutrients, sediment, and watershed loads. As recommended by Jones et al. (2012), in-Bay modeling of PCBs and other contaminants should coordinate with and build on these other efforts.

**Study Objective and Applicable RMP Management Questions**

The objective of this study is to develop a strategy and multi-year workplan for modeling PCBs and other contaminants in the Bay. This study would address, or contribute to addressing, the following management questions articulated in the PCB Strategy.

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

The study would also address the overarching RMP management questions that are related to these PCB management questions.

The study would also address the specific management questions of current interest that were mentioned above.

1. What would be the impact of focused management of PMU watersheds?
2. Should Bay segments be managed separately?
3. What would be the impact of in-Bay hotspot management at the segment scale?
4. Should the TMDL timeline be extended beyond 2030?

**Approach**

The funding for this study would cover time for Craig Jones of Integral Consulting and SFEI staff to perform the following tasks:

1. Review available reports and plans
2. Perform simple tasks to support the strategy
   a. Re-evaluation of one-box model sensitivity analysis
3. Team meetings to develop outline of draft strategy
   a. Including coordination with nutrients, sediment, and SPL workgroups
4. Present outline of draft strategy to PCBWG for discussion
5. Write draft report on strategy
   a. Including proposed modeling five year workplan
6. Write final report on strategy
Budget

SFEI Labor

<table>
<thead>
<tr>
<th>Task</th>
<th>Cost</th>
</tr>
</thead>
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<tr>
<td>Review available reports and plans</td>
<td>$8,726</td>
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<tr>
<td>Perform simple tasks to support strategy</td>
<td>$3,805</td>
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<tr>
<td>Team meetings to develop outline of draft strategy</td>
<td>$6,954</td>
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<tr>
<td>Present outline of draft strategy to PCBWG for discussion</td>
<td>$2,745</td>
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<tr>
<td>Write draft report on strategy</td>
<td>$9,035</td>
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<tr>
<td>Write final report on strategy</td>
<td>$3,786</td>
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Total                                                   $35,050

SFEI budget includes hours for Jay Davis, Don Yee, Scott Dusterhoff, Melissa Foley, Dave Senn, and a NMS modeler

Craig Jones Labor: $10,000

Total Project Cost: $45,050

References


Oram, J.J. and J.A. Davis. 2008. Draft report - A Forecast Model of Long-Term PCB Fate in San Francisco Bay. SFEI.

PCB Workgroup 2021 Proposal #2: Monitoring the Impact of Remediation Actions on San Leandro Bay Recovery from PCB Contamination

Summary: This study would establish baseline conditions to monitor the downstream effect of changes in PCBs discharged to the San Leandro Bay priority margin unit expected from recent and pending upstream management actions in the watershed. Cleanup action at a former GE facility, an expected major source of PCBs to the watershed, has largely been completed. Cleanup activity at a second site (Union Pacific Railroad) is planned in the next few years. Passive samplers and sediment traps will be deployed downstream of completed and planned management activities to monitor PCBs entering San Leandro Bay. A reference site in San Leandro Bay further away from direct watershed influences will also be sampled to evaluate spatial patterns. Since management activities either have been implemented or are planned in the next few years, there is urgency to establishing baseline conditions in order to document expected the effect of changes in PCBs entering the bay.

Proposed Funding: Full study: $104,020 from RMP ($60,000 in-kind from Stanford) Reduced study: $77,830 from RMP ($42,000 from Stanford) - fewer stations and replicates

Oversight group: PCB Workgroup

Proposed by: Diana Lin and Don Yee, SFEI Yeo-Myoung Cho and Richard Luthy, Stanford University

Time Sensitive: Yes. Management activities in the watershed either have been implemented or are planned in the next few years, there is urgency to establish baseline conditions. Also, the match from Stanford is available now, but may not be in the future.

Table 1: Tasks and Timeline

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Due Date</th>
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<tbody>
<tr>
<td>Task 1: Field reconnaissance</td>
<td>January 2021</td>
</tr>
<tr>
<td>Task 2: Field sampling</td>
<td>March 2021</td>
</tr>
<tr>
<td>Task 3: Laboratory analysis</td>
<td>October 2021</td>
</tr>
<tr>
<td>Task 4: Draft technical report</td>
<td>March 2022</td>
</tr>
<tr>
<td>Task 5: Final technical report</td>
<td>June 2022</td>
</tr>
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</table>
Introduction and Background

The objective of this study is to establish baseline conditions with which to monitor the effect of changes in PCBs discharged to San Leandro Bay (SLB) priority margin unit (PMU) to evaluate and document benefits from upstream management action. The overarching goal of the RMP PCB studies in the PMUs is to establish a conceptual foundation and baseline data to evaluate the response of these nearshore environments to reductions in PCB loading from adjoining watersheds. San Leandro Bay is of particular interest because management activity at two identified sources of PCBs in the watershed are in different stages of completion. The former GE station is expected to be a major source of PCBs, and cleanup action at the site has largely been completed. The site has been completely capped and building demolition is planned. Cleanup activity is expected at another expected PCB source, at the former Union Pacific Railroad (UPRR) site, over the next few years. All of these activities are expected to provide ongoing and future PCB loading reductions to SLB.

The RMP recently completed a conceptual model study of the SLB PMU (Yee et al. 2019). A mass balance model for SLB projected that the water and surficial sediment concentrations will decrease proportionally to reductions in loading, but the timing and magnitude of any decline is highly uncertain. The recommended monitoring strategy included monitoring near-field immediately downstream of major management actions.

Passive sampling devices (PSDs) have been developed to measure the freely dissolved water concentration for non-polar organic contaminants, and there is growing use of PSDs to monitor site recovery from management activities for PCBs and PAHs (Menzie et al., 2016) and DDTs (Lin et al., 2015 and Lin et al. 2017). In 2016, a pro bono study led by Dr. Yeo-Myoung Cho at Stanford University demonstrated the use of PSDs in San Leandro Bay by measuring dissolved water concentration profiles above and below the sediment-water interface at three locations in San Leandro Bay. Water concentrations of dissolved PCBs were measured in San Leandro Bay at the mouth of East Creek Channel (ECM20m), near Damon Slough (SLBsub1), and in Airport Channel (G4g). PCB concentration differences among the three sites were consistent with surface sediment concentrations and expected loadings from upstream sources.

The goal of this study is to establish a baseline for monitoring the in-Bay response to expected PCB loading reductions from cleanup actions at the GE and UPRR sites. Monitoring results are important for demonstrating the benefit of loading reductions and validating the conceptual model (Yee et al., 2019). Additionally, this study will develop new tools and methods to monitor stormwater flows that may be more widely implemented.

Study Objective and Applicable RMP Management Questions

The objective of this study is to examine PCB loadings and spatial patterns in the SLB PMU through the use of PSDs and sediment traps. This study would address, or contribute to addressing, the following management questions articulated in the PCB Strategy.
1. What are the rates of recovery of the Bay, its segments, and in-Bay contaminated sites from PCB contamination?

2. What are the present PCB loads and long-term trends in loading from each of the major pathways?

4. Which small tributaries and contaminated margin sites are the highest priorities for cleanup?

5. What management actions have the greatest potential for accelerating recovery or reducing exposure?

6. What are the near-term effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

The study would also address the overarching RMP management questions that are related to these PCB management questions.

**Approach**

Freely dissolved water concentration equivalents (obtained from PSDs) and suspended sediment samples will be collected at a total of eight sites in San Leandro Bay PMU during the wet season to develop baseline conditions to evaluate future changes in PCB loadings expected from remediation actions at the GE and UPRR site (Figure 1). The sampling sites are briefly described below:

1. East Creek Channel downstream of GE site
2. East Creek Channel further downstream near Interstate-880
3. ECM20 where East Creek Channel discharges in San Leandro Bay, which was also sampled using passive samplers in 2016
4. Damon Slough Channel downstream of UPRR site
5. Damon Slough Channel further downstream near Interstate-880
6. SLBsub1 where Damon Slough Channel discharges to San Leandro Bay, which was also sampled using passive samplers in 2016
7. San Leandro Bay between East Creek and Damon Slough
8. G4g in Airport Channel, which was also sampled using passive samplers in 2016. This site can be used as the reference site away from direct influence downstream of GE and UPRR site.

New configurations of sampling equipment will be designed and developed in collaboration with Stanford University to collect suspended sediment using sediment traps and to measure dissolved water concentration profiles using passive samplers. Each equipment setup is expected to include a small sediment trap, and PSD measurements at 3 depths (overlying water, overlying water water within 1 cm above sediment-water interface, porewater within 1 cm below sediment-water-interface). Duplicates will be collected at all sites. One field blank (sediment trap and passive sampler) will be collected during deployment and retrieval. These passive sampling efforts would demonstrate a new approach that could enable the RMP to monitor stormwater at locations that have previously been difficult to sample during storms, reducing reliance on manual collection.
of samples from individual storm events. Similar approaches have been deployed in other locations to evaluate recovery from upstream contamination sources (Lin et al., 2017).

The purpose of sampling at Sites 1-6 is to analyze PCBs concentrations along a transect downstream of the GE and UPRR site. Site 1 will be selected as close to the GE site as possible, and Site 4 will be selected as close to the UPRR site as possible. Site 7 in San Leandro Bay is added to understand mixing nearfield of these slough inputs in San Leandro Bay. Site 8 is included to provide a reference site away from direct influence from the GE and UPRR site. This site was also sampled in 2016. Because there is the possibility of losing sampling equipment or samples (e.g., washout during high stormwater flows, or accidental or intentional removal by humans or animals) we will deploy replicate sets of equipment at nearby sites along the transect, and prioritize analysis of the most successful/least disturbed collections after samples have been retrieved.

We expect this sampling design to provide valuable baseline data to monitor future changes in tributary loadings in East Creek channel and Damon Slough Channel. Future monitoring efforts may potentially rely on PSDs to monitor PCB concentration trends and complement monitoring trends in the sediment and biota. We expect that passive samplers may correlate well with trends in these other matrices and reduce the number of sediment and biota samples needed, reducing future sampling and analytical costs, or help track progress in environments where sufficient biota for pollutant analysis are sporadically or not at all found (such as in a recent effort to find shiner surfperch and small fish in Steinberger Slough, another PMU).

Stanford collaborators will also provide in-kind support to the project by collecting and analyzing additional samples. In particular, Stanford will conduct equilibrium partitioning studies to understand equilibrium concentrations with suspended sediment using PSDs. This will be compared with measured dissolved water concentrations in the field.

To reduce budget cost for the current year, lower priority sediment traps and passive samplers can be archived and analyzed at a later date. For this lower cost option, replicates would only be analyzed at sites 1 and 4, and samples from site 7 would not be analyzed. This would reduce the number of analyzed sediment samples to 9 (7 sites + 2 replicates). The number of passive samplers analyzed would also be reduced, with samples from site 7 archived. A decision and budget to analyze archived samples could be made at a later date.
Figure 1: Proposed sampling locations (Google earth image).
Table 2: Estimated RMP Budget

<table>
<thead>
<tr>
<th>Budget Item</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project management</td>
<td>$2,300</td>
</tr>
<tr>
<td>Field reconnaissance and sampling</td>
<td>$12,300</td>
</tr>
<tr>
<td>Reporting</td>
<td>$10,000</td>
</tr>
<tr>
<td>Stanford subcontract - labor and equipment</td>
<td>$12,000</td>
</tr>
<tr>
<td>Stanford subcontract - PCB laboratory analysis ($1,000/sample)</td>
<td>$30,000 - $48,000</td>
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<tr>
<td>SGS Axys subcontract - PCB laboratory analysis ($1,000/sample)</td>
<td>$9,000 - $16,000</td>
</tr>
<tr>
<td>Subcontract - TOC, grain size, total solids laboratory analysis ($170/sample)</td>
<td>$1,530 - $4,240</td>
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<tr>
<td>Direct costs - travel and shipping</td>
<td>$700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$77,830 - $104,020</strong></td>
</tr>
</tbody>
</table>

*Project management*
This includes SFEI labor costs to manage project budget, develop contracts, and coordinate activities with subcontractors.

*Field reconnaissance and sampling*
This includes estimated SFEI labor hours to conduct field reconnaissance to develop sampling design and support Stanford University to collect field samples. Hours estimated includes preparing field equipment, and traveling to the field to deploy and retrieve equipment on separate days.

*Reporting*
This includes estimated SFEI labor hours needed to support Stanford researchers for developing a report. Reporting cost are significantly reduced because Yeo-Myoung Cho of Stanford University will be the lead author for the report. Dr. Cho’s time spent report writing will be an in-kind contribution from Stanford.

*Stanford sub-contract*
Field sampling will be led by Stanford University, who will provide sediment trap and passive sampling equipment, and deploy and retrieve equipment. Estimated sub-contract costs for field sampling activity including use of equipment and labor is estimated to be $12,000. Analytical cost for analysis of passive samplers is estimated to be $48,000 based on $1,000/sample for 48 samples (8 sites * 3 passive sampling depths * 2 duplicates). The lower budget range is to reduce the analytical budget to $30,000 for analysis of passive samplers at seven sites and replicates at two sites.
Subcontract - sediment analysis for PCB, grain size, TOC, and total solids
Analytical cost for analysis of sediment samples is estimated to be $1000/sediment sample for PCBs (209 congeners) by SGS Axys and $170/sample for grain size, TOC, and total solids (by another contract lab). The number of sediment samples for analysis is 16 (8 sites * 2 sediment trap samples) If the solids mass in the sediment trap is too low to analyze as a sediment sample, it may instead be analyzed as a water sample, with subsamples taken for SSC and TOC. The reduced budget is for analysis of seven field samples and two replicates (total 9 samples).

Direct costs
This includes estimated costs for shipping sediment samples to SGS Axys for analysis (British Columbia, Canada), and direct cost for purchasing equipment and travel to site.

Matching Funds from Stanford
In addition to the in-kind contribution from Stanford for report preparation ($20,000), other in-kind contribution items include: 1) field equipment and samplers (~$1K), 2) sediment trap processing (~$2K), and 3) Stanford's additional PSD sampling and equilibrium validation studies (~ $32-$40K). The overall amount of matching funds is estimated to be at least $42K.

<table>
<thead>
<tr>
<th>Amount from RMP:</th>
<th>$77,830 - $104,020</th>
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<tbody>
<tr>
<td>In-kind from Stanford:</td>
<td>$42,000 - 60,000</td>
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<tr>
<td>Total Budget</td>
<td>$137,830 - $164,020</td>
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References