# SPLWG Special Study Proposals

# Proposal 1:
# SPLWG Special Study Proposal: STLS Program Management

**Summary:** The goal of the Small Tributary Loading Strategy (STLS) over the next few years is to continue to provide information to RMP stakeholders and the public that directly supports the identification and management of PCBs, Hg, and other pollutant sources, concentrations, and loads in stormwater, and the determination of trends in relation to management efforts in San Francisco Bay. This proposal is to provide STLS program management to help achieve this goal. The outcome of this task is to maintain communication with the BASMAA program and Water Board representatives via in-person and phone meetings, and to participate in RMP inter-workgroup meetings aimed at maximizing efficient collaboration. Specific activities include coordinating regular meetings, planning and developing agendas and materials, preparing meeting summaries, and attendance at key external meetings.

**Estimated Cost:** $30k
**Oversight Group:** STLS/SPLWG
**Proposed by:** Alicia Gilbreath, Lester McKee, Tan Zi, Jennifer Hunt (SFEI)
**Time Sensitive:** Yes - since the RMP does not provide general program funds for this level of coordination, this budget is needed each year to run the program.

## Proposed Deliverables and Timeline

| Deliverable | Due Date |
|---|---|
| Prepare for and hold 6 STLS meetings during calendar year 2021 | 12/2021 |
| Meeting summary and action items for each meeting | 12/2021 |
| Prepare for and hold 4 inter-workgroup meetings during calendar year 2021 | 12/2021 |
| Meeting summary and action items for each inter-workgroup meeting | 12/2021 |

## Background

The San Francisco Bay Hg and PCB TMDLs call for a reduction in loads by 50 and 90% by 2028 and 2030, respectively. In response, the Municipal Regional Permit for Stormwater (MRP) (SFRWQCB 2009, SFRWQCB 2015) called for a range of actions, including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of sediments and trace contaminant loads on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. In response, the STLS was formed to develop and outline a set of evolving management questions (SFEI, 2009) that have been used as the guiding principles for the region's stormwater-related activities.

## Study Objectives and Applicable RMP Management Questions

With an increased focus on collaboration synergy between projects funded by the RMP and those funded directly by BASMAA, it was recognized in 2009 that an annual budget allocation was needed to ensure constant and efficient communication between RMP program staff and BASMAA and Water Board representatives. This objective helps ensure quality planning and implementation of projects that aim to answer the priority management questions.

**Table 1.** Study objectives and questions relevant to RMP management questions.

| Management Question | Study Objective | Example Information Application |
|---|---|---|
| Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay? | Provide constant and efficient communication between RMP program staff and BASMAA and Water Board representatives to ensure quality planning and implementation of projects that aim to answer the management questions. | N/A |
| Q2: Which are the "high-leverage" small tributaries that contribute or potentially contribute most to Bay impairment by POCs? | | N/A |
| Q3: How are loads or concentrations of POCs from small tributaries changing on a decadal scale? | | N/A |
| Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff? | | N/A |
| Q5: What are the measured and projected impacts of management action(s) on loads or concentrations of POCs from small tributaries, and what management action(s) should be implemented in the region to have the greatest impact? | | N/A |

## Approach

RMP staff will manage the STLS process and STLS projects, as well as work with the other workgroups to maximize efficient collaborative efforts within the RMP. Tasks include:

- Six STLS meetings/year

- Four RMP inter-workgroup meetings/year
- Planning and developing meeting agendas and materials
- Preparing meeting summaries, and
- Attending key external meetings (e.g., BASMAA Monitoring / POC Committee meeting, BASMAA BoD meetings)

## Budget

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

**Table 2.** Proposed budget.

| Expense | Estimated Hours | Estimated Cost |
|---|---:|---:|
| Project Staff | 177 | $30,000 |
| ***Grand Total*** | 177 | $30,000 |

Budget Justification
*Labor Costs:* 177 hours of staff time to prepare for, hold, and follow up on six STLS, four inter-workgroup, and two external meetings over calendar year 2021.

## Reporting

Written meeting summaries are prepared after every meeting and archived and available upon request. A list of action items and due dates are also maintained.

## References

SFEI, 2009. RMP Small Tributaries Loading Strategy. A report prepared by the strategy team (L McKee, A Feng, C Sommers, R Looker) for the Regional Monitoring Program for Water Quality. SFEI Contribution #585. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/sites/default/files/biblio_files/Small_Tributary_Loading_Strategy_FINAL.pdf

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

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

# Proposal 2:
# SPLWG Special Study Proposal: Small Tributaries Loading POC Watershed Reconnaissance Monitoring

**Summary:** Over the past six years, the RMP has funded reconnaissance monitoring to identify high leverage watersheds and subwatersheds for PCBs and Hg sources and to develop a remote sampler method to decrease costs and increase ease of data collection. We propose to continue reconnaissance monitoring during winter storms in WY 2021. The study will help gain further knowledge and understanding of PCB and Hg concentrations, particle ratios, congener patterns, and yields in areas that have a disproportionately larger area of older urban and industrial land use. In addition, this sampling program is being coordinated with the needs of the ECWG (for specific emerging contaminants), the microplastics WG, and the PCBWG, all who pay a share of the field cost, their own analytical and data management costs. It is primarily a field study and the level of effort will be tailored to the amount of budget available and collaboration with the other groups. There is no phasing proposed.

**Estimated Cost: $120k**
**Oversight Group:** STLS/SPLWG
**Proposed by:** A Gilbreath, J Hunt, D Yee, T Zi, and L McKee (SFEI)
**Time Sensitive:** No, but this is a continuation of a multi-year study to identify PCB and Hg sources to inform management actions.

## Proposed Deliverables and Timeline

| Deliverable | Due Date |
|---|---|
| Selected site list | 09/2020 |
| Wet season water samples collected and sent to the labs for analysis | 04/2021 |
| Laboratory analysis, QA & Data Management | 09/2021 |
| Interpretation & reporting for BASMAA | 02/2021 |
| Draft report | 03/2021 |
| Final report | 06/2021 |

## Background

The San Francisco Bay Hg and PCB TMDLs call for a 50% reduction in Hg loads by 2028 and a 90% reduction in PCB loads by 2030. In supporting these TMDLs, the

Municipal Regional Permit for Stormwater (MRP) (SFRWQCB 2009, SFRWQCB 2015) called for a range of actions, including gaining a better understanding of which Bay tributaries contribute the most loading to sensitive areas of biological interest on the Bay margin, better quantification of sediment and trace contaminant loads on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. In response to the MRP requirements and information needs, the Small Tributaries Loadings Strategy (STLS) outlined a set of evolving management questions (SFEI, 2009) that have been used as the guiding principles for the region's stormwater-related activities.

During water years (WYs) 2015-2020, the RMP funded a watershed characterization reconnaissance study to locate high leverage watersheds and subwatersheds, and develop a remote sampler method designed to decrease costs and increase ease of data collection. Over the six years of watershed characterization, in addition to a similar effort in WY 2011 (McKee et al., 2012), a total of 86 sites have been characterized for PCB and Hg concentrations and particle ratios during at least one storm using this method (McKee et al., 2016; Gilbreath et al., 2017; Gilbreath et al., 2018, Gilbreath et al., 2019, Gilbreath et al., 2020)[1]. A total of 17 sites have now been characterized using the remote sampler methods. Through these efforts, it was discovered that PCB concentrations at 25 sites are highly elevated (> 0.2 ug/g, or > 140x the TMDL target[2]), and four sites have highly elevated Hg concentrations (> 1 ug/g, or > 5x the TMDL target)3. Initial results of the remote sampling pilot indicate a reasonable correlation between the particle concentrations observed in the remote samplers and particle ratios observed in the manual water samples. As such, the remote sampler method has been adopted as a screening tool.

## Study Objectives and Applicable RMP Management Questions

This study will provide information essential to understanding concentrations of PCBs and Hg in a broad number of sites around the Bay. The objectives of the project and how the information will be used are shown in Table 1 relative to the Sources, Pathways, and Loadings Workgroup (SPLWG) high-level management questions. In addition, site selection is being coordinated with ECWG (for specific emerging contaminants), the microplastics WG, and the PCBWG. Thus, the study objectives are broader than just those of SPLWG.

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[1] Data were also collected by the Santa Clara and San Mateo Stormwater programs using the same watershed characterization reconnaissance study design.

[2] The TMDL did not have a concentration target but rather a total load target, and through back calculation we determined the average concentration required to meet that target.

[3] Note: These data only reflect WYs 2011, 2015-2019; results have not yet been returned for sampling in WY 2020)

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

| Management Question | Study Objective | Example Information Application |
|---|---|---|
| Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay? | N/A | N/A |
| Q2: Which are the “high-leverage” small tributaries that contribute or potentially contribute most to Bay impairment by POCs? | N/A | N/A |
| Q3: How are loads or concentrations of POCs from small tributaries changing on a decadal scale? | N/A | N/A |
| Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff? | Use remote samplers to collect samples at new locations as a screening method to determine if they are likely high-leverage. Use these results to rank these locations relative to each other and sources.<br><br>Use manual water composite sampling methods to revisit previously sampled locations | Where are the highest leverage watersheds for potential management action?<br><br>How variable are concentrations from storm to storm? |
| Q5: What are the measured and projected impacts of management action(s) on loads or concentrations of POCs from small tributaries, and what management action(s) should be implemented in the region to have the greatest impact? | Provide a regional map of concentrations and loads for baseline comparison to the effects of BMP application. | Where should BMPs be located to have the greatest benefit for water quality? |

## Approach

A wet weather field monitoring program is proposed to continue during the winter months of WY 2021 sampling at watersheds, subwatersheds, or finer scales to assess management priority. The sampling program will largely mimic the program implemented during WYs 2011, and 2015-2020 (McKee et al., 2012; Gilbreath et al., 2020 in review);

the improved decision tree for site and storm characteristics developed by the advanced data analysis in WY 2019 (McKee et al., 2019; Davis and Gilbreath, 2009) will also be used to augment the program.

- Monitoring Design
  At each site, collect a minimum of:
  - o One composite stormwater sample during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using a manual sampling techniques OR
  - o One remote sampler (settled suspended sediment) sample during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using a Hamlin Sampler or Walling tube, dependent on site logistics (Walling Tubes are best suited for a natural bed while Hamlin Samplers are superior in storm drains or concrete channels).

- Site Selection
  - o Objective 1: Find new high-leverage watersheds or sub-watershed areas (watershed locations near the Bay margin or further downstream than the source tracking approach). Remote samplers,where feasible, are ideal for this objective, although manual sampling may also be used. Approximately half of the field labor and analysis budget will be allocated to this effort.
  - o Objective 2: Re-sample locations where additional information is necessary to inform ranking. In these watersheds, manual water composite sampling methods will be used for direct comparison to the prior data. Approximately half of the field labor and analysis budget will be allocated to this effort.
  - o Other selection criteria:
    - ▪ Larger watersheds with an existing USGS gauge
    - ▪ Re-sample potential false negatives
    - ▪ PCB Strategy priority margin unit watersheds
    - ▪ Nested sampling design to track sources upstream in known polluted areas to help better define source areas and management options
- Number of sites: Dependent on site logistics, proximal site associations, analytes, budget, and other factors; likely 10-12 sites.
- The 2020 analyte list will be continued (PCBs, Hg, SSC) in WY 2021. In addition, other analytes will be sampled and paid for through ECWG piggyback.

## Budget

The following budget represents estimated costs for this proposed special study (Table 2). Efforts and costs can be scaled back by reducing the number of sampling sites.

**Table 2.** Proposed budget.

| Expense | Estimated hours | Estimated Cost |
|---|---|---|
| ***Labor*** | | |
| Project Staff | 600 | $40,000 |
| Project Management | 70 | $12,000 |
| Data Management | 175 | $20,000 |
| Reporting | 147 | $20,000 |
| ***Subcontracts*** | | |
| SGS AXYS Analytical, Brooks Applied Laboratories, USGS | | $22,000 |
| ***Direct Costs*** | | |
| Equipment | | $1,500 |
| Travel | | $1,000 |
| Shipping | | $3,500 |
| **Grand Total** | 600 | **$120,000** |

Budget Justification

*Field Costs:* This special study proposal has a budget of $120,000, which includes up to $40,000 devoted to stormwater sample collection (site selection and reconnaissance, permit applications, development of sample collection protocols, and field work for approximately 10 sites).

Every effort will be made to minimize field costs through monitoring multiple sites per team per storm, and leveraging existing stormwater monitoring activities of the RMPs.

*Laboratory Costs:* Up to 14 independent samples will be analyzed, including field duplicates and a field blank. Analyses will be conducted for PCBs, mercury, and suspended sediment concentration.

*Data Management Costs:* Data services will include quality assurance and upload to CEDEN.

*Reporting Costs:* Preparation of a draft and final report on the results will be completed.

Note, if there was a guarantee of two more years on this project (i.e. funding in 2022 also), we could save money by missing a data management and reporting year.

## Reporting

The outcome of the study will be a concise technical report. The main objective of this report will be to report and rank concentrations and particle ratios observed at each location and compare these to existing data. The methods developed in the Advanced Data Analysis project may be applied.

## References

Davis, J. A.; Gilbreath, A. N. 2019. Small tributaries pollutants of concern reconnaissance monitoring: pilot evaluation of source areas using PCB congener data. SFEI Contribution No. 956. San Francisco Estuary Institute: Richmond, CA. https://www.sfei.org/documents/small-tributaries-pollutants-concern-reconnaissance-monitoring-pilot-evaluation-source

Gilbreath, A.N., Hunt, J.A., Yee, D., and McKee, L.J., 2017. Pollutants of concern reconnaissance monitoring final progress report, water years 2015 and 2016. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 817. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/sites/default/files/biblio_files/SFEI%20WY2016%20POC%20monitorng%20report%20FINAL%20June2017.pdf

Gilbreath, A.N., Wu, J., Hunt, J.A., and McKee, L.J., 2018. Pollutants of concern reconnaissance monitoring final progress report, water years 2015, 2016, and 2017. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Contribution No. 840. San Francisco Estuary Institute, Richmond, CA. https://www.sfei.org/documents/pollutants-concern-reconnaissance-monitoring-water-years-2015-2016-and-2017

Gilbreath, A.N., Hunt, J.A., Yee, D., and McKee, L.J., 2019. Pollutants of concern (POC) reconnaissance monitoring final progress report, water years (WYs) 2015 - 2018. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 942. San Francisco Estuary Institute, Richmond, CA. https://www.sfei.org/documents/pollutants-concern-reconnaissance-monitoring-water-years-2015-2018

Gilbreath, A.N., Hunt, J.A., Yee, D., and McKee, L.J., 2020 (in final revisions). Pollutants of concern (POC) reconnaissance monitoring final progress report, water years (WYs) 2015 - 2019. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 987. San Francisco Estuary Institute, Richmond, CA.

McKee, L.J., Gilbreath, A.N., Hunt, J.A., and Greenfield, B.K., 2012. Pollutants of concern (POC) loads monitoring data, Water Year (WY) 2011. A technical report prepared for the Regional

Monitoring Program for Water Quality in San Francisco Bay (RMP), Small Tributaries Loading Strategy (STLS). Contribution No. 680. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/documents/pollutants-concern-poc-loads-monitoring-data-water-year-wy-2011

McKee, L.J., Gilbreath, A.N., Yee, D., and Hunt, J.A., 2016. Pollutants of concern (POC) reconnaissance monitoring draft progress report, water year (WY) 2015. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 787. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/documents/pollutants-concern-poc-reconnaissance-monitoring-final-progress-report-water-year-wy-2015

McKee, L.J., Gilbreath, A.N., Hunt, J.A., Wu, J., Yee, D., and Davis, J.A., 2019. Small tributaries pollutants of concern reconnaissance monitoring: Loads and yields-based prioritization methodology pilot study. SFEI Contribution No. 817. San Francisco Estuary Institute, Richmond, California. https://www.sfei.org/documents/small-tributaries-pollutants-concern-reconnaissance-monitoring-loads-and-yields-based

SFEI, 2009. RMP Small Tributaries Loading Strategy. A report prepared by the strategy team (L McKee, A Feng, C Sommers, R Looker) for the Regional Monitoring Program for Water Quality. Contribution No. 585. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/sites/default/files/biblio_files/Small_Tributary_Loading_Strategy_FINAL.pdf

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

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

# Proposal 3:
# SPLWG Special Study Proposal: POC Data Interpretation - Advanced Data Analysis

**Summary:** Reconnaissance data collected during single storms have provided evidence to support enhanced management efforts in watersheds with high PCB concentrations in water and on sediment particles. However, sources have not been located in all watersheds exhibiting high concentrations and data have had limited value for prioritizing management efforts in watersheds exhibiting moderate or lower concentrations, yet these watersheds likely contain patches with elevated concentrations. In 2018, the RMP funded the development of advanced data analysis methods based on loads and yields and congener patterns to add further information to support management decisions (McKee et al., 2019; Davis and Gilbreath, 2019). With method development complete (2018 funding), the loads and yields methods were applied with 2019 and 2020 funding to data that were in existence up to WY 2019 (>140 watersheds) and the congener method was applied in 75 watersheds (not completed for Santa Clara and San Mateo Counties watershed program data) (McKee et al., in preparation). Ranking based on yields reveal some stark contrasts to those based on concentrations and particle ratios.

This project proposes to complete the analysis on all remaining sites (WYs 2020, 2021) and those sampled by San Mateo and Santa Clara Programs for which there is congener data for both water and sediment/soils. The output will be a comprehensive and inclusive comparative ranking of all watersheds based on concentrations, particle ratios, loads, yields, and congener patterns. The outcome will be more informed decisions on watersheds to prioritize for enhanced management or further sampling.

**Estimated Cost:**
Option 1: $30k (Analysis of water samples only)
Option 2: $50k (Analysis of water and sediment/soils samples)

**Oversight Group:** STLS/ SPLWG
**Proposed by:** L McKee, A Gilbreath, J Hunt, T Zi, J Davis, and D Yee (SFEI)
**Time Sensitive:** No.

## Proposed Deliverables and Timeline

| Deliverable | Due Date |
|---|---|
| Compilation of data | 09/2021 |
| Analysis of data and presentation of draft results | 09/2021 |
| Draft a brief report for STLS review | 10/2021 |
| Draft report for SPLWG review | 11/2021 |
| Address review comments and finalize report | 02/2022 |

## Background

During water years (WYs) 2011 and 2015-2020, the RMP funded efforts to characterize a total of 86 sites during at least one storm for PCB and Hg concentrations and particle ratios (the ratio of a pollutant concentrations measured in a stormwater sample to the suspended sediment concentration in that same sample) (e.g. Gilbreath et al., 2019; Gilbreath et al., 2020, in review). These data build upon and complement a more detailed sampling program that was carried out at eight locations where samples were taken during multiple storms over a minimum of two years (WYs 2003-2010, 2012-2014) (McKee et al., 2015). Water concentrations and particle ratios from these studies have been ranked from high to low to help identify watersheds for management consideration (Gilbreath et al., 2020 in review). In addition, the same field monitoring protocol was also implemented in WYs 2016-2019 by the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program (EOA, 2020a and 2020b). These data, along with over 1000 samples from soils and sediment in storm drains and around potential source properties (Yee and McKee, 2010; Geosyntec and EOA, 2017), are being used by BASMAA to identify focal areas for management action.

When concentrations are high, water samples, coupled with other evidence—including land use and source area characteristics, records review, soil concentration surveys, and facility inspections—have identified a number of small industrial watersheds and properties within them of management interest. However, evidence and a rationale for management prioritization in watersheds and on potential source properties exhibiting moderate or lower concentrations are still lacking.

To address this gap, new techniques were developed and applied in 2018 and 2019 as a pilot study to support decision making. The first technique used data from seven well-sampled watersheds, and stormwater concentration data collected from 15 locations in the Guadalupe River watershed along with rainfall data, RWSM watershed specific runoff coefficients, empirical storm rainfall-load relationships and land-use data to estimate storm-based yields for standard-sized storms. The pilot study results provided new evidence on areas to consider for management. For example, East Gish Road Storm drain, which had previously ranked as moderate for concentrations and particle ratios was identified as higher yielding and higher leverage (McKee et al., 2019).

The second technique used congeners representative of the four most commonly used Aroclors as indicators to estimate relative contributions of source areas in watersheds to the concentrations and congener profile seen at the outlet (Davis and Gilbreath, 2019). As an example, data from the Pulgas Pump Station watershed indicated that outflow was uniquely dominated by Aroclors 1242 and 1260 due to two distinct source areas in the watershed. If the Aroclor 1242 source area were to be eliminated, it was estimated that the load exported could be reduced by 50% or more.

In addition, a third method was trialed using a combination of partial least squares regression (PLSR) and random forest (RF) statistical routines to explore the relationships of PCB water concentrations, particle ratios, and area yields with a large array of candidate climatic and landscape variables. The most influential variables largely matched our expectations (e.g., storm load correlated to total event rainfall, and yield [load per area] inversely correlated to percent open space), but some results were ambiguous (e.g., positive or negative correlations to antecedent rainfall, depending on watershed). At this time, we are unable to use this method to identify a combination of variables that point to new sites of interest or alternative methods for accounting for other factors (e.g., for normalizing ranking metrics). This method will not be pursued any further.

Overall, the results from the first two methods provide additional supporting evidence for management focus and indicate that reducing loads in sub-areas with higher yields or specific congener profiles within the larger watersheds may help speed the recovery of the nearby receiving waters and ultimately the Bay as a whole. With method development complete (2018 funding), the loads and yields methods were applied with 2019 and 2020 funding to data that were in existence up to WY 2019 (>140 watersheds) and the congener method was applied in 75 watersheds (not completed for Santa Clara and San Mateo Counties watershed program data) (McKee et al., in preparation).

Preliminary comparisons of rankings between particle ratio (PR), water concentration (WC) and yields reveal stark differences. Ten of the 20 top ranked sites based on PR and 12 of the 20 top ranked sites based on WC dropped out of the top 20 sites ranked by yields. As anticipated, a number of medium and lowly ranked sites for PR and WC were ranked high in relation to yields. Some examples include Line 12A at Shellmound Pedestrian Br. (Alameda County), where a storm of 0.80 inches was sampled in 2018. The watershed is 10.48 sqkm and 14% RWSM old industrial and source areas, old commercial, and old transportation. This watershed jumped in ranking from the middle third of the overall data set for PR and WC to a ranking of 2 for yields. SM-RCY-333A (San Mateo County), was sampled during a relatively small storm of 0.27 inches in 2018. The watershed is just 0.06 sqkm in size and 11% RWSM old industrial and source areas, old commercial, and old transportation. This watershed jumped in ranking from the bottom half of the overall data set for PR and WC to a ranking of 4 for yields. Rodeo Ck at Seacliff Pedestrian Br., (Contra Costa County), was sampled during a relatively large storm of 0.84 in 2017. The watershed is 23.41 sqkm and 4% RWSM old industrial and source areas, old commercial, and old transportation. This watershed, like Line 12A at Shellmound Pedestrian Br., also exhibited a relatively low rank for PR and a moderate rank for WC but was ranked 5 based on yields. These two watersheds very aptly illustrate the role that dilution of clean water and clean sediment from uncontaminated land uses plays in masking sources in these watersheds when using WC or PR as indicators. The last example is another micro catchment, that of Seabord Ave Storm Drain 050GAC580 (Santa Clara County) with a watershed area of 1.35 sqkm but 98% RWSM old industrial and source areas, old commercial, and old transportation. This watershed was sampled in 2014 during a very rare large storm. It ranked 43 for PR and 31 for WC in the overall data set but ranked 8 for yields. These watersheds are all great illustrations of the power of the new methods to reveal new aspects of the data as weight of evidence for management consideration. Watersheds exhibiting the highest yields tended to be dominated by Aroclors 1248 and 1254. Aroclor 1248 was primarily used in capacitors (45% of the total volume use) and Aroclor 1254 was primarily used in transformers (25% of the total volume use) and caulk and joint sealants (Erickson and Kaley, 2011). More work is needed on filling out these source profile trends.

The 2021 funding proposed would enable the completion of the analysis to all remaining sites, those sites sampled during WY 2020 and 2021 and those sampled by San Mateo and Santa Clara Programs for which there is congener data suitable for source profiling. The objective is to provide a full and comprehensive assessment of yields and congener patterns to support the weight of evidence approach for management decisions or further sampling. As the data set expands, the method grows more powerful as a tool to support management.

## Study Objectives and Applicable RMP Management Questions

The study will provide information essential to understanding the relative importance of watersheds, subwatersheds, and source areas for management consideration in relation to reducing loading-based impacts of PCBs in San Francisco Bay. The objectives of the project and how the information will be used are shown in Table 1 relative to the Sources, Pathways, and Loadings Workgroup (SPLWG) high-level management questions.

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

| Management Question | Study Objective | Example Information Application |
|---|---|---|
| Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay? | Use load, yield, and congener-based analysis methods to identify watersheds, subwatersheds, and source areas for management consideration. | The project will provide new insights into relative loads for ~ 170 watershed locations. |
| Q2: Which are the "high-leverage" small tributaries that contribute or potentially contribute most to Bay impairment by POCs? | | The project will identify high yielding areas and areas with unique congener patterns in relation to general concentrations found in Bay sediment and fish tissue. |
| Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff? | | The study will compare yields and congener profiles for individual source areas to those of other sources within subwatersheds and watersheds to identify areas that may be of higher interest. |

## Approach

Budget option A ($29,700): Collate stormwater data on concentrations and congener patterns in watershed storm data collected in 2020 and 2021 by the RMP (~ 16 sites). In addition, collate congener data collected by the San Mateo and Santa Clara County programs in 2016-2018 (~80 sites). Apply loads and yields and congener based data analysis techniques to all these data and combine with the results from the 2020 analysis (McKee and Gilbreath 2020 in preparation).

Budget option B ($50,360): Carry out all the work in Option A plus collate the 1000+ samples from soils and sediment in storm drains and from potential source properties (Yee and McKee, 2010; Geosyntec and EOA, 2017), and apply the congener method to sites that are nested inside the watersheds sampled during storms. The power of combining the two methods along with the congener profiles for the sediment/soils samples will be further explored with the overall outcome being a comparative ranking of all data collected to date using concentrations, particle ratios, loads, yields, and congeners.

Method 3 will not go forward further at this time, but in 2019 the WG advisors recommended that it be considered again in the future as a parallel analysis to support modeling decisions.

**Method 1. Yields-based Comparisons**
Yields for watersheds where there are suitable concentration data collected during storms will be estimated using the following steps:

1. Using storm-based rainfall data and estimates of runoff from the RWSM, storm volume will be estimated
2. The storm volume will be combined with estimated event mean concentration data to estimate storm loads
3. Storm loads will be adjusted to a standard sized storm
4. Standard storm yields will be estimated by dividing the loads by the source areas of interest in the given watershed or subwatershed
5. These will then be used to compare sites and estimate relative leverage to identify areas for management consideration

**Method 2. Congener Profile-based Comparisons**
The relative contributions of four different Aroclor mixtures (1242, 1248, 1254, and 1260) in stormwater and sediment will be estimated using the following steps.

1. Determine the percent contributions of four relatively unique indicator congener sets for each Aroclor that are a major contributor to the overall sum of PCBs (Aroclor 1242: PCBs 18, 28, 31, 33; Aroclor 1248: 44, 49, 66, 70; Aroclor 1254: PCBs 487, 101, 110, 118; Aroclor 1260: PCBs 149, 170, 180, 187).
2. For each sediment, soil, or water sample, compute the index as the sum of the percent contributions of the indicator congeners for each Aroclor.
3. Standardize the index for each Aroclor as a % of the sum of the four indices.
4. The data for the Aroclor indices are then binned into the following categories
    a. greater than or equal to 40% of the sum of Aroclor indices (primary contributor);
    b. greater than or equal to 20% and less than 40% of the sum of Aroclor indices (secondary contributor); and
    c. less than 20% of the sum of Aroclor indices (minor contributor).
5. Compare the profiles found in individual water and sediment/soils samples in upstream areas of a watershed with those observed at the outlet further down to make inferences about relative contributions.

## Budget

The budget is based on experience from work completed in 2018-2020.

| | Option A (water) | | Option B (water and soils/sediment) | |
|---|---|---|---|---|
| **Expense** | **Estimated Hours** | **Estimated Cost** | **Estimated Hours** | **Estimated Cost** |
| Project Staff | 140 | $22,400 | 240 | $38,400 |
| Senior Management Review | 6 | $1,140 | 8 | $1,520 |
| Project/Contract Management | 8 | $1,360 | 12 | $2,040 |
| Data Technical Services | 8 | $1,200 | 16 | $2,400 |
| GIS Services | 24 | $3,600 | 40 | $6,000 |
| **Grand Total** | | **$29,700** | | **$50,360** |

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# Proposal 4:
# SPLWG Special Study Proposal: Regional Model Development to Support Watershed Loads and Trends

**Summary:** The 2018 Small Tributary Loading Strategy (STLS) prioritized further assessment of the spatial and regional estimates and temporal trends in Pollutants of Concern (POC) loads, and developed a 5-year plan for model development out to 2022. Although initially conceived as a tool for evaluating trends, advice provided at the 2019 SPLWG meeting placed the emphasis on developing a model to support better estimates of PCB and other POC loads, sediment, and emerging contaminants. The focus in 2020 is on developing and calibrating the hydrology model. Following the modeling implementation plan (MIP), this proposal is for funding in 2021 to complete the sediment model and continue working on the conceptual design of the POC model. The hydrology and sediment model, once established, will be used as a basis for POC modeling in subsequent years. Although there is a more general objective to support multiple pollutants, initially the model will be developed for PCBs and Hg. After PCB calibration and validation, the model will be used to evaluate PCB loadings at watershed and regional scales. Trends associated with control measures, land-use changes, or other scenarios could then be explored.

**Estimated Cost:** $150k
**Oversight Group:** STLS/SPLWG
**Proposed by:** Tan Zi and Lester McKee (SFEI)
**Time Sensitive:** Yes - this is the third year of a sequential four-year study

## Proposed Deliverables and Timeline

| Deliverable | Due Date |
|---|---|
| 2021 funding: Sediment model setup completed | 06/2021 |
| 2021 funding: Sediment model initial calibration ready for review | 08/2021 |
| 2021 funding: Sediment model calibration and documentation completed; PCB and Hg model data collation and general POCs model planning started | 12/2021 |
| 2022 funding: PCB and Hg model setup, calibration, review and documentation (2022 funding) | 2022 |
| 2023 funding: Collation of additional control measure data and receipt of updated land use[4]. Model application runs for answering RMP questions | 2023 |

## Background

The San Francisco Bay TMDLs call for a 50% reduction in Hg loads by 2028 and a 90% reduction in PCB loads by 2030, respectively. In supporting these TMDLs, the Municipal Regional Permit for Stormwater (MRP) (SFRWQCB 2009, SFRWQCB 2015) called for the implementation of control measures to reduce PCB and Hg loads from urbanized tributaries. In addition, the MRP has identified additional information needs associated

[4] Note, although not contingent on this data set, the new dynamic regional watershed model will benefit from this data set in the application of water quality trends.

with improving understanding of sources, pathways, loads, trends, and management opportunities of POCs. In response to the MRP requirements and information needs, the Small Tributary Loading Strategy (STLS) was developed and outlined a set of management questions (MQs) that have been used as the guiding principles for the region's stormwater-related activities (Table 1; SFEI, 2009; Wu et al., 2018).

Over the past decade, the RMP and BASMAA have focused on Q1, Q2, and Q4. In recognition of the need to answer Q3, in particular Q3.2, the STLS team updated the Strategy in 2018 to include a trends component. The new Modeling and Trends Strategy identified the development of a regional watershed model as a priority, with an initial focus on POC loading, but prepared and developed in a way that would facilitate its use for evaluation of future trends. Although there is a more general objective to support multiple pollutants, initially the model will be developed for PCBs and Hg simply because we have the most loading data for these pollutants. But the regional model could also be developed to include other pollutants, such as contaminants of emerging concern (CECs) and nutrients, and provide a mechanism for evaluating management actions and management impact on future trends of POC loads or concentrations in support of Q5.

The 2018 Modeling and Trends Strategy included a multi-year work plan that would obtain initial answers to loading questions by 2022 and the trends or other questions in years beyond. The first step of this plan, completed in 2019, was to develop a Modeling Implementation Plan (MIP) to guide model development, which included model platform and development procedures and a timeline (Wu and McKee, 2019). The MIP was reviewed by the STLS in April 2019 and the Sources, Pathways, and Loadings Workgroup (SPLWG) in May 2019 and approved later in 2019. Subsequently, RMP funding was provided for 2020, and so far, the tasks of model data collection and model setup have been completed. This proposal is for 2021 funding to implement the third year of the multi-year work plan, which includes completing calibration and validation of the regional model for hydrology and suspended sediment. The hydrology and sediment model will be used as the basis for POC modeling in 2022.

## Study Objectives and Applicable RMP Management Questions

The study will provide information essential to understanding spatial and temporal characteristics of hydrology and sediment loads, at the scales of both individual watersheds and the region as a whole in relation to the SPLWG high-level management questions.

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

| Management Question | Study Objective | Example Information Application |
|---|---|---|
| Q1: What are the loads or concentrations of Pollutants of Concern (POCs) from small tributaries to the Bay? | Complete a regional hydrology and sediment model to serve as the basis for | The model will produce an estimate of flow and sediment concentrations and loads at each individual watershed. |

| | | |
|---|---|---|
| Q2: Which are the “high-leverage” small tributaries that contribute or potentially contribute most to Bay impairment by POCs? | POC modeling and as the first stage of regional model development to support trends evaluation. | Estimates produced by the regional model at each individual watershed can be compared to explore relative loading rates and how those pass into specific priority margin areas, operational landscape units, or RMP Bay segments. |
| Q3: How are loads or concentrations of POCs from small tributaries changing on a decadal scale? | | Time series of flow and sediment loads for 1999-2018 can be used to assess trends for individual watersheds and the region as a whole. |
| Q4: Which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff? | | Model outputs of flow and sediment will help identify high yield areas that can be targeted for management actions. |
| Q5: What are the measured and projected impacts of management action(s) on loads or concentrations of POCs from small tributaries, and what management action(s) should be implemented in the region to have the greatest impact? | | Management actions, both existing and planned or anticipated, could be evaluated in the model through scenario runs. |

## Approach

A phased approach is being employed to develop the regional model, starting with hydrology, followed by suspended sediment, and then by POCs. The following table lays out the whole road map for the whole project from inception (2015) through to the end of the 5-year plan as it currently stands. The tasks being proposed for completion in 2021 represents the second phase of model development and will primarily cover development and calibration of the suspended sediment model, and the beginnings of a POC model. In addition, any necessary improvements to the hydrology model will also be carried out. Overall and generally, the following road map lays out a standard model development and application process. Although there is a more general objective to support multiple pollutants, initially the model will be developed for PCBs and Hg, the analytes for which we have the most field data.

| Year | Budget ($k) | Deliverable | Completion Date |
|---|---|---|---|
| 2015-2018 | 235 | Loads and trends strategy conception; Conceptual model development; Statistical analysis of PCB trends in Guadalupe River; Completion of Small Tributaries Loading Strategy: Modeling and trends Strategy. | 2018 |
| 2019 | 60 | Modeling Implementation Plan | 2019 |
| 2020 | 100 | Hydrology initial calibration ready for review | 08/2020 |
| | | Hydrology calibration completed<br>Sediment model data collation and model setup started | 12/2020 |
| 2021 | 150 | Review and incorporation of new land use data[5]. | 03/2021 |
| | | Sediment model setup completed | 06/2021 |
| | | Sediment model initial calibration ready for review | 08/2021 |
| | | Sediment model calibration and documentation completed<br>PCB and Hg model data collation and general POCs model planning started | 12/2021 |
| 2022 | 150 | PCB and Hg model setup completed | 02/2022 |
| | | Regional watershed model webpage (optional element) will be drafted for SPLWG review | 04/2022 |
| | | PCB and Hg model initial calibration ready for review | 08/2022 |
| | | PCB and Hg model calibration and documentation completed | 12/2022 |
| 2023 | 150 | Collation of additional control measure data and receipt of updated land use[2]<br>Model application runs for answering RMP questions. Options may include:<br>a) Model refinements for better representation of spatial variability<br>b) Model refinements for assessing trends associated control measure implementation and land use[2] change<br>c) Characterization of sedimentation process in flood control channels<br>d) Assessment of future scenarios loading estimates<br>e) Model development for other contaminants Linking and doing model runs to support models of physical and biological processes on the Bay margins or in the Bay | 12/2023 |

[5] Note, although not contingent on this updated land use data set, the new dynamic regional watershed model will benefit from this data set in the application of water quality trends

## Budget

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

**Table 2.** Proposed budget.

| Expense | Estimated Hours | Estimated Cost |
|---|---|---|
| Project Staff (Modeling) | 700 | $100,000 |
| RMP staff and stakeholder interactions and SPLWG review | 120 | $30,000 |
| Project/Contract management | | |
| Data technical services | 80 | $10,000 |
| GIS services | 80 | $10,000 |
| ***Total*** | ***980*** | ***$150,000*** |

Budget Justification

*Labor Costs:* Staff time to perform calibration/verification, process model results, and write up technical reports; to collect and process GIS data and construct a webpage; consult on water quality and control measure data and get technical support from related other parties; and senior staff contributions and review.

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

## Reporting

- Annual Model Development presentations to STLS and SPLWG will be prepared.
- Improvements to model documentation will be appended each year as the model development evolves.
- Regional watershed model webpage drafted for SPLWG review by May 2022.

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# Proposal 5:

## SPLWG SEP project ideas

### SEP projects fit into a programmatic vision

| Project | 1 Updated Bay Area land use data | 2 Monitoring to support modeling loads and trends | 3 GSI and BMP performance studies | 4 RWSM maintenance | 5 Mallard Island monitoring for loads and trends | 6 Integrated watershed-Bay modeling strategy |
|---|---|---|---|---|---|---|
| Q1: What are the small tributaries loads or concs of POC to the Bay? | X | X | | X | X | |
| Q2: Which are the "high-leverage" small tributaries that contribute most to POC Bay impairment? | X | X | | X | | X |
| Q3: How are POC loads or concs changing over decades? | X | X | X | | X | X |
| Q4: Which sources or source areas provide the greatest opportunities for reductions of POCs? | X | X | X | | | |
| Q5: What are the measured and projected impacts of BMPs on POC loads or concs, and what management action) will have the greatest impact? | X | X | X | X | | X |

1. **Updated Bay Area Land Use Layer, $50k, T Hale, L McKee**

**(Note, although this has been on the SEP list for 3 years, given the urgency of the opportunity afforded by a collaboration with MTC, this is now being considered for RMP discretionary funds)**

Geographic information on land use forms the basis of data and information generated to inform many key planning, management, and policy decisions. The first comprehensive information on Bay Area land use was released by ABAG in 1995, updated in 2000, and again in 2005 to reflect the (then) latest information about land use on a parcel basis. The dataset has since been used for all kinds of applications (both inside and outside of ABAG), most of which it was never designed to support. RMP program examples include:

- Identifying contaminant sources;

- Supporting monitoring designs and modeling runoff of water, sediment, and contaminants (Note, although not contingent on this data set, the new dynamic regional watershed model being developed by the RMP will benefit from this data set in the application of water quality trends);
- Determining ways to manage runoff;
- Predicting future contaminant loads for reasonable assurance that loads will be reduced;
- Mapping ecological value of urban areas.

However, given the passage of time and population growth since 2000 that has added 1.5 million people to the region, with associated changes in land-development patterns, this land-use data set is in need of a major update. Having since absorbed the Association of Bay Area Governments (ABAG), the Metropolitan Transport Commission (MTC) is now working on an update of Bay Area land use and plans to have a draft ready for publication in March 2021. This presents a narrow window of opportunity for the RMP to influence this vital dataset in meaningful ways.

The stated objectives of the MTC land-use update are to support Plan Bay Area by identifying geographic matters related to transportation improvement, housing development and barriers, land inventory and opportunity analysis, and issues of equity. At MTC's invitation, we have an opportunity to work with them to ensure that the newly updated land-use dataset is not only optimal for their stated purposes, but also addresses the broad array of uses of interest to Bay RMP stakeholders, as much as possible. Prospective tasks assigned to RMP staff, based on two meetings with MTC staff, would include:

| | | | |
|---|---|---|---|
| a) Advisory Coordination | Convening an RMP advisory group and integrating with the MTC technical advisory group | 80 hours | $15k |
| b) Data Modeling Support | Reconcile RMP advice and input with MTC data formatting and attributes in a consultative capacity. | 60 hours | $11k |
| c) Data Collection and Validation | Work with MTC staff to collect and transform data relevant to RMP stakeholders – e.g., data identifying sensitive habitats, the nexus between water quality and land use, hydrology patterns, or ecological attributes – into quality-assured, regionally consistent land-use information for integration into the MTC dataset. | 140 hours | $24k |

This proposal aims to help MTC generate a one-time regional update of basic land-use information for the Bay Area to support timely planning and assessment needs within the RMP community. Working with RMP staff, MTC plans to develop the product in a way that can then be updated regularly on 2-5 year intervals.

2. **Monitoring to Support Regional Model, $100-$280k/year, L McKee, A Gilbreath**

PCB and Hg loading data collected in eight watersheds have supported estimates of single watershed loads, regional load estimates, and estimates of land-use-specific concentrations and yields using the Regional Watershed Spreadsheet model (RWSM). However, to date, only data collected in the Guadalupe River span a long enough period for trend assessment. During 2020, we are developing a monitoring design with support and advice from our modeling advisors and STLS stakeholders that will support the regional model that is currently being developed. The results of this small project should be available in late summer. To calibrate a regional model for loads and trends, we need data from multiple wet seasons, collected over more than a decade in several watersheds, covering a range of land uses and management efforts. In this study, we propose to sample for PCBs, Hg, and suspended sediments during storms over the wet season to produce water quality loads data for one, two, or three field locations (depending on funding) likely already instrumented with flow gauging and provide this data to the public via the online RMP CD3 tool, with a supporting short technical metadata report outlining site selection rationale, field set up, quality assurance, loads computation methods, and results. Calibration or verification of the regional dynamic model being developed will be an immediate use of the data but the data could also be used for future recalibrations of the RWSM. Other RMP workgroups who have a need for concentration or loading data could piggyback on the field sampling program. To improve calibration of the flow and sediment components of the regional model, monitoring at four locations over two water years (2020 and 2021) has been funded by an SEP. No decision has yet been made as to which locations out of the eight previously sampled for PCBs and Hg or these new four now being sampled for SSC would be selected for further sampling. The RMP has a small project in 2020 to develop the site selection rationale.

Estimated Cost: $100k/year (1 sampling site);
$190k/year (2 sampling sites);
$280k/year (3 sampling sites)

3. **GSI and BMP Performance Studies, $75-$500k, A Gilbreath, L McKee, Don Yee**

The municipal regional stormwater permit (MRP) requires that stormwater permittees implement Green Stormwater Infrastructure (GSI) to address load reductions for PCBs and Hg. A number of studies carried out by BASMAA, SFEI, and CALTRANS have demonstrated the efficacy of bioretention devices (rain gardens, tree-well planters, bioswales) to capture and retain PCBs at high rates and Hg at moderate rates. However, only one study (El Cerrito rain garden: Gilbreath et al., 2019) has analyzed performance over multiple years and determined the build-up rates and locations of concentrations within the soil media. These results to date do not adequately represent the breadth of GSI features with differing design configurations, catchment land uses, and micro climates. In addition, there are many remaining questions about the best design layout, media composition, and vegetation and submerged zone effects on performance, and how these differ between PCBs and Hg and other contaminants such as nutrients. GSI implementation in the Bay Area is on the rise, at great cost, so work to improve our understanding of their initial and longer term performance is beneficial. This study proposal provides a menu of study options for addressing some key data gaps:

- **PCB fate during building demolitions: Quantification of loads and the effectiveness of controls:** Provision C.12.f of the MRP requires Permittees to manage PCB-containing building materials during demolition to reduce loads discharged to municipal storm drains from demolition via vehicle track-out, airborne releases, soil erosion, or stormwater runoff. Studies suggest that soil concentrations around intact buildings decrease by 20-50 fold over distances of 30 feet. Likewise, residential areas in the vicinity of buildings containing PCBs are known to have the highest PCB concentrations in air relative to sub-urban areas that are further distant from PCB sources. But we are not aware of any systematic studies quantifying mass released via track-out, airborne releases, soil erosion, or stormwater runoff during and after a demolition or the effectiveness of control measures at minimizing these transport and dispersion processes. We propose to convene a technical review committee to assist in the prioritization of information gaps, design, implementation and oversight of a statistically unbiased study of PCBs release vectors and effectiveness of control measures in relation to stormwater loading during building demolition. ($400-$500k)

- **GSI long term PCB and Hg monitoring and soil build-up:** The only long term Bay Area GSI study completed to date showed possible performance trends over time and that PCBs, Hg, and MeHg were all present at the highest concentrations in the upper 10 cm in the surface media layers; and that if residential (0.23 mg/kg) or industrial (0.94 mg/kg) screening concentrations for PCBs were to be maintained, the surface media layer near the inlet would need to be removed and replaced annually and the rest of the unit would need replacement every eight years. We propose to complete a second long-term study at a previously sampled bioretention system (likely selected from the BASMAA pilot studies with stakeholder oversight on the decision) to provide data for supporting decisions about media replacement and overall maintenance schedules. ($125-$200k)

- **GSI media depth in relation to PCB and Hg capture:** After bioretention media composition, a critical design parameter is the media depth. Most of the contaminant mass captured was retained in the top 10 cm of soil, with filtration likely being the most important capture mechanism for PCBs and possibly also for Hg. Because PCBs have been shown to deposit in shallow (< 10 cm) regions of biofiltration cells, a shallower design could allow for cheaper and easier implementation of rain gardens in contaminated areas where there are depth constraints (e.g., utilities, groundwater) with effectively equivalent levels of PCB removal. Various design depths should be studied within the constraints of vegetation needs and detention capacity to understand how performance increases with depth and at what depth performance plateaus. This study would develop performance curves for bioretention depth to help managers better understand when shallower installations may be possible and acceptably meet performance requirements. ($100-$150k)

- **GSI media composition in relation to PCB and Hg capture:** Studies have shown that GSI media composition can have significant impacts on the degree of capture and adsorption. The use of organic amendments such as mulch and/or leaf compost in bioretention media may increase metal sorption capacity but with the potential trade-off of decreased permeability, increased nutrient release, and desorption with dissolution of organic carbon. For the latter, pH amendments may help prevent such leaching. Activated carbon and biochar amendments may also help reduce contaminant mobility. Some improvements have been seen in BASMAA tests of biochars in column lab studies of PCB capture, but Hg removal is less certain (Phoenix, Agrosorb showed some promise). No field application results are available. As a follow on from the BASMAA study, we will carry out a field analysis of various types of soil amendments (e.g., Phoenix, Agrosorb, Sunriver, or BioChar Solutions biochars) in bioretention soil media, in a series of paired field studies using a coring approach to look at contaminant capture efficiency or mobility with depth. Sites should be selected to avoid irreducible low concentration drainage management areas. ($200-$250k)

- **GSI plant investigation for Hg accumulation and harvest:** Vegetation has counter impacts on Hg removal effectiveness. Vegetation can be used to counter the creation of macropores due to cracking during the dry periods, but vegetation may also conversely encourage macropore generation due to root growth and senescence. Plants can also hyperaccumulate Hg and other metals. We propose to study the effects of vegetation on macropore development and hyperaccumulation in a selection of GSI bioretention units with and without irrigation and the related maintenance implications. ($100-$125k)

4. **Regional Watershed Spreadsheet Model Update, $10-$25k, L McKee, A Gilbreath**

The Regional Watershed Spreadsheet Model (RWSM) was developed to estimate average annual regional and sub-regional scale loads for the San Francisco Bay Area. It is part of a class of deterministic empirical models based on the volume-concentration method. The strengths of volume-concentration models include relatively fewer data input requirements, explicit selection of land uses, suitability for hypothesis testing, and manual and automated calibration or verification procedures that enable estimates of error and bias as a component of the outputs. In the Bay Area, it has so far been used for providing first approximations of regional (Bay wide) and sub-regional (e.g., individual county, Bay segment, or priority margin unit) estimates of PCBs, Hg, Cu, nutrients, and microplastics. The cost to use it for microplastics was < $15k whereas to develop and run a dynamic simulation model for the whole Bay Area for a new contaminant would take approximately 4-5x that budget. At such a minimal cost, maintaining it for use with any future contaminant of interest is a priority. With stakeholder consultation on priorities, we propose to carry out RWSM maintenance that may include:

- Flow recalibration using a new calibration period (1991-2020) that is better aligned with the contaminant data used for the contaminant models calibration;

- Flow recalibration addressing technical challenges associated the inaccuracies in the 2005 land use data and modernizing the land use layer to 2018 (MTC planned publication March 2021);
- Improving the Hg model calibration;
- Developing the model for other contaminants (about $10k per contaminant).

5. **Mallard Island Monitoring for Loads and Trends, $150-$200k/ wet season, L McKee**

contaminants from the Central Valley watershed pass into San Francisco Bay via the channel adjacent to Mallard Island near Pittsburg, CA. The RMP, working with USGS and DWR data, studied this location for six years (Water Years 2002-06, 2010), collecting water samples during storms and analyzing these for suspended sediment, PCBs, OC pesticides, PAHs, PBDEs, dioxins/furans, mercury speciation (total, dissolved, methyl and acid labile), and selenium. contaminant loads were estimated by extending RMP suspended sediment load methods published in 2006 using 1990s data. Subsequent USGS work suggests a step decrease in North Bay SSC since 1999, so the earlier published regression-based formulas may no longer be accurate given likely changes in vertical and horizontal SSC variation in the water column and recent restoration of some Delta Islands. Since the Delta is the largest single supply for sediments and many contaminants to San Francisco Bay, errors in loading estimates from this source may have large impacts on net Bay budgets. With stakeholder consultation on priorities for Bay and Delta RMPs (e.g., nutrient and other contaminant mass balances and trends), we propose studies of contaminant loading processes at Mallard Island that may include:

- Collecting appropriate data on vertical and horizontal variation of SSC and velocity over 25-hour tidal cycles and using this data to update or verify the dispersive-advective flux ratio published by the RMP in 2006, or derive an alternate computation method;
- Monitoring average years and larger storm years to better estimate maximum loading rates during very wet years and overall average annual loads. This can be used to reduce uncertainties in changes in management and trends for sediment or loads and speciation of selenium and other contaminants. Initial or greatly improved loading information may also be obtained on:
    - Nutrient concentrations and loads during storm events (supporting a better understanding of baseline nutrient loads and trends from changing wastewater treatment practices);
    - Current use pesticides (pyrethroids, carbaryl and fipronil) concentrations and loads during storm events;
    - Contaminants of emerging concern concentrations and loads during storm events;

The estimated costs, including data management, are $150-$200k per wet season depending on the chosen suite of contaminants analyzed, other funding sources, and coordination needs.

6. **Integrated Watershed-Bay Modeling Strategy, $60-$80k, T Zi**

There is interest by some RMP stakeholders for a modeling workgroup to oversee and optimize the development of an integrated modeling program to address RMP questions. To answer priority management questions, the RMP carries out a wide variety of systematic field exercises to collect chemical data on water, sediment, and biological samples. More recently, the RMP and its partners have been developing and employing modeling techniques to predict the physical, chemical, and biological character of the Bay and its watershed in places and during times (including the future) when no empirical samples are available. However, the various modeling efforts (watershed and Bay dynamic simulation models, food web models, and mass balance conceptual box models of the Bay and Bay margins) are minimally or not integrated, and used as stand-alone tools to answer project specific questions. An integrated usage of varied monitoring data and modeling tools will be useful to understand linkages between ecosystem components and better answer some of the management questions (for instance, sediment and contaminant transport from watersheds, to and through the nearshore margins, and to the open Bay). As a first step, we propose to develop a long-term programmatic integrative strategy to develop a suite of linked and co-developed modeling tools that are inclusive of needs across all the working groups of the RMP. The outcome of this proposal would be a long-term vision document, “Integrated Watershed-Bay Modeling Strategy.”