RMP Sources Pathways and Loading Workgroup Meeting Agenda
May 23, 2018, 9:30 am - 4:30 pm
SFEI 1st floor conference room, 4911 Central Avenue, Richmond, CA 94804

Remote Access: Phone: **+1.415.594.5500**; Access Code: **943-326-397#**; Slides: https://join.me/sfei-conf-cw1

Desired outcomes:

1. Review of recent technical products.
2. Recommendations from the SPLWG regarding which special studies will be forwarded to the Technical Review Committee for 2019 funding consideration.

	Title	Time	Staff
1	**Introduction** ● Welcome, introductions, ground rules, goals for today ● Overview of RMP planning	9:30	Philip Trowbridge (SFEI)
2a	**Information: Review of management questions** SF Bay Water Board staff will provide an overview of the management priorities that are important considerations when planning future research.	9:40	Richard Looker (Water Board)
2b	**Information: Overview of related stormwater program activities and objectives** BASMAA member agencies are key partners for the RMP and they conduct monitoring as part of the Small Tributaries Loading Strategy (STLS). Representatives will provide an update on their recent activities and management objectives to help provide context for the meeting.	9:50	Chris Sommers (BASMAA)
3	**Information: Overview of proposed special studies** Summary of proposed project, with time for Q&A. A broader discussion of all proposals will be held in Agenda Item 4. Formal recommendations for funding will be made during Agenda Item 5. **Attachments** ● Proposal overview table Desired Outcomes: feedback on the merits of the proposals as part of the overall program (Note specific technical feedback can be given during each proposal/presentation or general feedback can be summarized and programmatically contextualized as part of the discussion period in item 4).	10:00	Philip Trowbridge (SFEI)
3a	**Proposal: Reconnaissance characterization monitoring** Update on recent work to identify high leverage watersheds for POCs and proposed special studies for next steps. **Attachments** ● Proposal 1 & Add On: Reconnaissance characterization monitoring Agenda package, pages 16-23	10:05	Alicia Gilbreath (SFEI)

	Break	10:25	
3b	**Proposal: Advanced data analysis** Initial results on advanced data analysis and proposed work for next year. **Attachments** ● Proposal 2: Advanced data analysis Agenda package, pages 24-28	10:40	Lester McKee (SFEI)
	Lunch	12:10	
3c	**Proposal: Trends strategy** Draft trends strategy and proposed special studies. **Attachments:** ● Proposal 3: Regional model development to support trends strategy Agenda package, pages 29-32	12:50	Jing Wu (SFEI)
3d	**Proposal: Contaminants of Emerging Concern (CECs) stormwater screening** Two-year study to screen stormwater for alternative flame retardants and other CECs. The Emerging Contaminants Workgroup considers this proposal a high priority. **Attachments** ● Proposal 4: CECs stormwater screening Agenda package, pages 33-42	2:00	Rebecca Sutton (SFEI)
	Break	2:30	
4	**Discussion: Recommended studies for 2019** Desired Outcome: The workgroup will review and critique the proposals presented within the broader context of a 5-year STLS work plan and Bay stormwater and watersheds research for information needs.	2:40	Philip Trowbridge (SFEI)
5	**Decision: Recommendations for 2019 special studies funding** RMP Special Studies are identified for funding through a three-step process. Strategy teams/ Workgroups reach a consensus and recommend studies for funding to the Technical Review Committee (TRC). The TRC weighs input from all workgroups and then recommends a slate of studies to the Steering Committee. The Steering Committee makes the final funding decision. To avoid an actual or perceived conflict of interest, the Principal Investigators for proposed special studies are expected to leave the room during this item. Desired Outcomes: Recommendations from the SPLWG to the TRC regarding which special studies should be funded in 2019 and their order of priority.	4:00	Facilitation by Chris Sommers (EOA)
6	**Report out on Recommendations**	4:20	Chris Sommers (EOA)
	Adjourn	4:30	

Final reports since last WG meeting

- 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, California. http://www.sfei.org/sites/default/files/biblio_files/SFEI%20WY2016%20POC%20monitorng%20report%20FINAL%20June2017.pdf
- McKee, L.J., Bonnema, A., David, N., Davis, J.A., Franz, A., Grace, R., Greenfield, B.K., Gilbreath, A.N., Grosso, C., Heim, W.A., Hunt, J.A., Leatherbarrow, J.E., Lowe, S., Pearce, S.A., Ross, J.R.M., and Yee, D., 2017. Long-term variation in concentrations and mass loads in a semi-arid watershed influenced by historic mercury mining and urban pollutant sources. Science of the Total Environment V605–606, 482-497. https://www.sciencedirect.com/science/article/pii/S0048969717310483
- McKee, L.J., Gilbreath, A.N., Pearce, S.A. and Shimabuku, I., 2018. Guadalupe River mercury concentrations and loads during the large rare January 2017 storm. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG). Contribution No. 837. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/guadalupe-river-mercury-concentrations-and-loads-during-large-rare-january-2017-storm
- Wu, J., Gilbreath, A.N., McKee, L.J., 2017. Regional Watershed Spreadsheet Model (RWSM): Year 6 Progress Report. 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. 811. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/regional-watershed-spreadsheet-model-rwsm-year-6-final-report

Reports for SPLWG Review

- Pollutants of Concern Reconnaissance Monitoring Water Years 2015, 2016, and 2017 Draft Progress Report
- Statistical Methods Development and Sampling Design Optimization to Support Trends Analysis for Loads of Polychlorinated Biphenyls from the Guadalupe River in San Jose, California, USA
- Pollutants of Concern Small Tributaries Reconnaissance Monitoring Data: Site inter-comparison Methodologies, Draft Progress Report: Year 1
- RMP Small Tributaries Loading Strategy: Trends Strategy 2018 Draft
- Alternative Flame Retardants in San Francisco Bay: Synthesis and Strategy. Draft Technical Report

REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

sfei.org/rmp

RMP Sources Pathways and Loading Workgroup Meeting Summary
May 17th, 2017, 9:30am - 5:00pm

In attendance:

WG Member	Affiliation	Representing
Peter Mangarella	Geosyntec	Science Advisor
Mike Stenstrom	UCLA	Science Advisor
Kelly Moran	TDC Environmental	Science Advisor
Dan Cain	USGS	Science Advisor
Lori Sprague	USGS	Science Advisor
Bob Hirsch	USGS	Science Advisor
Barbara Mahler	USGS	Science Advisor
Dave Schoellhammer	USGS	
Chris Sommers	EOA	SCVURPPP
Arleen Feng	ACCWP	ACCWP, BASMAA
Lisa Sabin	EOA	
Bonne DeBerry	EOA	SMCCWP
Luisa Valiela	US EPA	
Richard Looker	SFB Regional Water Quality Control Board	
Jan O'Hara	SFB Regional Water Quality Control Board	
Carrie Austin	SFB Regional Water Quality Control Board	
Luisa Valiela	EPA Region 9	
Lisa Sabin Austin	Geosyntec	Contra Costa County
Aroon Melwani	AMS	SFEI
Paul Salop	AMS	
Hardeep Takhar	State Water Resources Control Board	
Bridgette DeShields		SFEI TRC

SFEI/ RMP Staff:

Lester McKee, Phil Trowbridge, Alicia Gilbreath, Don Yee, Jen Hunt, Jay Davis, Jing Wu, Becky Sutton

1 Introduction

Introductions were made. The primary goal of the meeting was to solicit advice on special studies for RMP 2018 which will be presented to the RMP technical review committee (TRC) for review on June 8th and for a funding decision at the RMP Steering Committee meeting on July 19th.

2a Information: Overview of SPL activities and objectives and recent high level outcomes

Alicia Gilbreath provided a summary of the primary stormwater management questions that are now part of the Small Tributary Loading Strategy (STLS). In question is the general shift away from loading studies and reconnaissance characterisation studies towards trends monitoring starting with the 2018 budget. As illustrated in the proposed special studies set, there remains a mix and some contention as to if it will be possible to cost effectively see a trend in stormwater. Alicia Gilbreath also reviewed the deliverables completed in the last year and provided a preview near complete deliverables in the context of the meeting.

2b Information: Review of management questions – how are they evolving?

Richard Looker presented a review of the MRP management questions. He noted that the RMP has its origins in permit requirements for stormwater and wastewater. The STLS is a subgroup of the RMP that works at the detailed level on loading studies and meets with greater frequency (monthly) than other RMP groups.

Kelly Moran asked if the SPL is responsive to the management of the Bay or just to the MRP. Richard Looker replied that it is both. Recently, the work under SPL has been more related to the MRP. Prior to 2010, work was more focused on better understanding Bay processes..

The primary focus of the permit is PCB load reduction. The goals are to implement PCBs control measures, assess PCBs load reductions, prepare Reasonable Assurance Analysis (RAA) for Green Infrastructure (GI), and to prepare implementation plans to achieve TMDL allocations. The numeric goal for GI implementation is to reduce PCBs by 3 kg/year by 2040. The RMP works close in coordination with stormwater permittees to collect needed information. There is sharing of information between the RMP and permittees and this will continue to be an important component of the joint stormwater programs. Per the permit, there needs to be some method for determining load reduction credits from control measures (aka accounting). There’s also a RAA requirement for green infrastructure. There needs to be a demonstration on how green infrastructure will be implemented to reduce PCB loads. This can be done at the municipal or regional level. Demonstration will be completed via modeling and accounting. It would be beneficial to harness the information flow between the RMP and the permittees for RAA. The preparation of implementation plans will go beyond the current MRP. Part of the process will be to look at what control measures will be implemented and what is the timeframe for implementation beyond MRP 2.0 to achieve TMDL allocations. The RMP can also play a role in this.

2c Information: Overview of related stormwater program activities and objectives

Chris Sommers provided an overview of the stormwater programs efforts. Chris Sommers noted that a lot of work goes into the STLS process from the Water Board, other RMP stakeholders, and the county clean water programs. The primary driver for this work is the PCB TMDL mandated load reductions. The programs are now implementing MRP 2.0 which will ID watershed management areas (WMAs) for

control measures, account for required load reductions, prepare RAA, and prepare PCB/Hg load reduction plans for achieving TMDL load reductions. There's going to be city plans developed for removing PCBs from demolished buildings. Also looking at PCBs in structural controls. A lot of work completed in the last 8 years to ID where PCBs are in the landscape including ID of old industrial areas before 1980, then classifying these areas into high/mod/low expected PCB concentrations. There has also been street dirt/stormwater monitoring to classify/validate the classifications, with ID of high priority catchments as an outcome.

There's a question about how to best interpret sample data, in particular how should the data be interpreted to answer management questions. The stormwater programs have developed a PCB threshold concentration that can be used to ID an upstream source. The threshold is somewhat arbitrary but important. There's still a question on how to classify catchments so that we cost effectively target the right catchments for further investigation. More information on determining the threshold and a data analysis method for the data will be helpful. Arleen Feng noted that source ID is a particularly vexing problem for stormwater managers.

There is and will continue to be a large effort by BASMAA to develop RAAs. BASMAA is developing an RAA guidance document that will be released in its final form in June 2017. RAAs will most likely be completed on a county wide basis using raw RMP and BASMAA data and synthesized information such the outputs from the regional watershed spreadsheet model (RWSM). RAAs will model or estimate PCB & Hg reduction from GI and source control demonstrating PCB load reduction effectiveness. Each municipality will also develop a GI plan for PCB/Hg reduction. There is a lot of planning happening under this permit term at the city and county level as well as connecting the planning efforts across different scales. Communication between RMP & BASMAA will be very important in developing RAAs. The RAAs needs to be approved by Regional Board staff as well as go through peer review.

Kelly Moran asked who will be the peer reviewers? Chris responded that this is undetermined at this point. There have been technical reviewers involved on the development of the RAA guidance document that have connections to the STLS. He also responded that it would be beneficial if the peer reviewers are consistent across the county programs.

Phil Trowbridge noted the primary question is to ask how can RMP data be best utilized for these different efforts?

3 Overview of proposed Special Studies

Don Yee summarized the work of the RMP STLS staff to lay out a roadmap of projects and timelines and linkages between the proposals and the broader program stormwater program. The primary goal for all STLS work is provide data to support management decisions on reducing the impacts of pollution and to help stakeholders measure regional changes in loads and concentrations compared to targets over time. For trends, how do we assess progress towards load reduction goals? The general elements & linkages for the roadmap include pilot studies, field programs, modeling tool application, and actual outputs from these efforts.

Arleen Feng asked if the framework is general or specific to particular contaminants. She also

commented that we still need to determine what the archetypes are and how they get applied - the word archetype may mean different things to different people.

Don Yee also outlined the questions for the advisers to consider throughout the day. Richard Looker expressed concern that if the synthesis component of the road map is pushed out to a much later date then we might get there and not have the right information to assess progress. He suggested spending time earlier to develop the synthesis tools since that is the most important output. Don Yee suggested that we have to start with something and then learn iteratively and adaptively. Need to build in flexibility to the road map.

Chris Sommers noted that the challenge is investing resources into developing the archetypes and learning adaptively. Resources are limited so we need to think about the archetype development on the front end. Jing Wu noted that a regional model will be a good tool to synthesize all of the information. Monitoring and modeling will proceed in parallel using the models to guide further monitoring. Richard Looker is looking for the mechanisms for feedback in the process to ensure it is iterative and adaptive. Arleen Feng noted that the difficulty is how to fit this process into the real world timing constraints of the MRP as well as the resource constraints. How will the permittees use incomplete information in the timeframe needed. We need a longer term planning effort to think through the issue. Peter Mangarella asked what proportion of resources will be utilized for trends? He noted that so far roughly 90% of resources has been spent on pilot study design and field program. Kelly Moran asked if there could be some time on the agenda to discuss the gaps in the proposals to which Phil responded that we have a large portion of the meeting time dedicated to getting feedback on the proposals and the program more generally for the last 2 hours of the day.

3a Proposal: Reconnaissance characterization monitoring

Alicia Gilbreath provided an overview of the reconnaissance monitoring to date. The reconnaissance method is a rapid and adaptable field technique to gather limited information from more locations across the region as a whole. The method is to sample one composite during one storm event at a site. The method was designed and first implemented during WY 2011 and then modified and implemented in WY 2015-2017. The main goal of using the method is to ID high leverage PCB source areas using a simple ranking technique that allows for simplistic comparisons between sites based on either stormwater concentrations or particle ratios. The simple rankings practice currently ignores variations in antecedent rainfall conditions, storm characteristics during sampling, and likely differences in source-release processes that are conceptually possible given watershed specific land use and source areas configurations . Despite these weaknesses, false positives are unlikely and so the method has helped to find about 15 locations of interest out of the 70+ sampled to-date by the RMP of the 4 years of monitoring using this technique, classifying high to low concentrations. It’s a flexible, relatively low cost method that also allows for sampling in tidally influenced channel systems as long at the storm times right relative to low or outgoing tides.

Alicia Gilbreath summarized the findings over the monitoring period. Mercury results show that most sites are above the TMDL waste load allocation of 0.2 ug/g. In 2016, a very high Hg concentrations was detected at Gilman Street in Berkeley. Similarly, for PCBs, most sites are above a conceptual PCB waste load allocation based on the regional stormwater waste load allocation of 2 kg PCBs compared

to either an estimate of regional flow or regional suspended sediment load.

Mike Stenstrom asked why do some old industrial areas not have PCBs? Alicia responded that the challenge is that old industrial areas cover a broad area of land use and source area types. In addition, the current reconnaissance method that measured concentrations in runoff from just one storm could result in false negatives (sampling storms that don't show the true loading character of a particular watershed).

To decrease the costs even further, we have also been piloting remote, unmanned sediment samplers. The data suggest that the samplers could be good for characterizing PCBs but not as good at characterizing Hg. One hypothesis is that Hg tends to be on finer grained particles that aren't entrained in the samplers as readily.

Questions for the advisers:
How can we improve the method?
Are we ready to shift to remote samplers? Could we also deploy samplers for longer time periods?
How can we adapt/refine the recon methods for broader uses?

Discussion
Mike Stenstrom noted that we could create our own land use categories to help with analysis. Old industrial is very important but not all old industrial areas are the same. Having data on land use is a very important part of a program. Mike Stenstrom recommended that we utilize the updated old industrial data layers that the counties have developed.

Kelly Moran noted that the current reconnaissance design isn't working as well as it could be - she noted that there is not a strong relationship between PCBs and old industrial area. She suggested that we need to look at the data in much more detail. We need to open up how to look at the data set - the field method has its limitations that may not be easily resolved without spending a lot more money but the data can be mined using more detailed interpretative techniques . She asked what are the other correlations in the data e.g. storm size etc. More analysis of the data are needed. If there is interest in using the data for wider purposes, moving to a probabilistic site selection process may be important. She also asked about collecting depositional sediments to which Arleen Feng responded that that stormwater programs are already doing a lot of that at the scales of individual properties but that that method is also prone to false negatives.

Dan Cain asked if we are seeing any surprises in the data? Alicia reiterated that we see low concentrations in area that were targeted because of high percentages of old industrial areas upstream. We also see very high concentrations occasionally but that these do not always correspond to the storm size sampled or to the percentage of old industrial upstream but do generally occur where there has been little redevelopment. But even when we find a high concentration, the larger question is where within the old industrial upstream should we be spending our efforts.

Barbara Mahler asked if we have looked at the bedded sediment data with the stormwater data? We have in the past but RMP staff haven't recently. BASMAA has looked at bedded sediment data to

inform where to monitor stormwater. Kelly Moran recommended doing more of these types of analyses. There's more questions about the middle part of the data set. If anything, the budget and oversight for this work may need to be increased.

Jay Davis noted that the false negatives are an issue so we could increase the frequency of sampling to try and reduce this. Lester commented that the field and interpretive methods as currently applied to not do a good job of predicting sources and processes within watersheds - congener profiles may help, as would a better understanding of the spatial distributions of possible sources properties and sampling more than one storm so that time and space can be reconciled.

Lisa Sabin suggested that we could look at imperviousness and concentration correlations using satellite data. Also look at antecedent rainfall and rainfall intensity relationships to the data. Can also look at transport processes to the analysis.

Mike Stenstrom noted that some watersheds wouldn't calibrate in the RWSM. This suggests that there's something different in those data and it needs to be investigated.

Barbara Mahler noted the congener profiles might provide more indication on why PCB levels are different amongst old industrial sites. Jay Davis responded that there are some interesting patterns in the congeners that we have looked at including storm differences and congener differences. Barbara Mahler noted that including the bedded sediment data in this analysis would be important. She suggested that Kerry Hornbuckle has been making progress on congener profiles so it would be good to look at some of her recent work.

Richard Looker commented on the importance of multiple uses of the data. The reconnaissance single storm data can tell us something about differences between sites but have not been very useful so far for supporting the RWSM. This could be improved by collecting data during multiple storms or better interpretative techniques, but he worries about the suggestion of doing super-composites that span longer term seasonal or multi storm samples that may yield data that may not be useful for other applications. He asked what do you lose by temporally integrating data via a long term method? This needs to be considered when making a decision to move to a long term composite design. It would be difficult to tease apart storm related data.

Don Yee asked how would you use temporally integrated samples in a model? Jing Wu noted that you wouldn't be able to use this type of sample in a dynamic model calibration. Richard Looker noted that you might ask a different question for a temporally integrated sample e.g. what is the impact of the five storm composite. Jing Wu noted that both grabs and longer term composites are useful for answering that question. Mike Stenstrom said in relation to calibrating the RWSM, that you can look at the residuals of an analysis and weight those residuals based on confidence and the impact on the calibration. There are formal techniques for weighting the data in the Box method of autocalibration.

Peter Mangarella noted that PCBs are mostly a "large storm" problem therefore the long term integrated samples are less informative. Better to focus efforts on large storm events.

- Lunchtime presentation (Guadalupe Hg loads during large storms)

3b Proposal: RWSM support

Jing Wu presented a summary of the RWSM proposal. The last phase of the RWSM provided a good model calibration. The results of this calibration indicate that old industrial areas produce the highest PCB concentrations and yields (mass per unit area). Well sampled watersheds were used for the calibration - the reconnaissance data from 40+ sites were experimented with extensively but were eventually dropped due to the unpredictability of false negatives within that data set. However, even with the use of the well sampled watershed data only, watersheds with high PCB concentrations tended to be under simulated in the model. For mercury, the model calibration suggested that agricultural and open space land uses should have the highest concentrations, followed by old urban, and then old industrial. Given the high sediment loads in rural areas, even with low particle ratios, this result seems generally logical. However, this results in a relatively low variation in simulated concentrations across the calibration watersheds that do not fully reflect the variability that has been observed leading us to the conclusion that the Hg model isn't very sensitive to the data and is not as well calibrated as the PCB model.

Mike Stenstrom suggested that the high point in the concentration data might be driving the poor calibration - drop the point out and see if it improves the calibration - something is going on in that watershed. Regional load estimates for both models are in the right order of magnitude despite calibration challenges for each model. The primary use of the model is to estimate annual regional contaminant loads. It also provides regionally averaged estimates of land use concentrations coefficients and yields as part of its output. It could be used in the future for generation of 1st order estimate for loads of other contaminants. However, given the average annual time step and the regionally calibrated nature, use of the model at scales more akin to management (sub-watersheds and source areas) is not recommended. In addition, the model is limited and shouldn't be used to measure spatial or temporal trends over time. The model also can't simulate landscape related BMP performance at the scales of individual storms when management practices must be tested for performance.

Barbara Mahler asked if the current work timeline is reasonable. Arleen Feng commented that the public use of the model is still under discussion - that in this case "public" more likely means BASMAA and its consultants. Chris Sommers noted that the RWSM will be beneficial to BASMAA's RAA modeling efforts where it is planned to use the regional coefficients as a starting point for the RAA model inputs or calibrations. We need to ensure that communication about the structure and performance and data needs of the County RAA models comes back to the RMP and SPL to help inform future directions.

3c Proposal: Alternative flame retardants

Arleen Feng presented the alternative flame retardant (AFR) proposal. There is a MRP permit requirement to address "relevant management information needs" for certain Emerging Contaminants (ECs) which is best conducted via a RMP special study. There is an existing RMP synthesis and strategy document that outlines the scope of the EC efforts under the Emerging Contaminant Workgroup (ECWG). Within the strategy document there's a task to develop a conceptual model of

AFRs with a 2019 placeholder of $80k which doesn't fit within the permit timeframe. This project will help coordinate between the EC & SPL workgroups with respect to AFRs.
Kelly Moran asked if this proposal fulfills a gap in the ECWG? Becky Sutton noted that the strategy does call for an AFR conceptual model and it will information the 2019 work. Kelly Moran also asked if the conceptual model will summarize how AFRs are used outdoors.Arleen Feng responded that it is still uncertain how the two groups will collaborate and how to integrate the varying needs of each workgroup. Kelly Moran asked if any research will be required to ID which consumer products have AFRs and in particular those that are outdoors? Becky Sutton did note that yes this is something we need to look at. We need to look at the various pathways of AFRs to the Bay and get good information for the next phase that will occur within ECWG. Kelly Moran noted the distinction between pathways and sources. Becky Sutton noted that these are important components to consider in this proposed project. Jan O'Hara noted that the outdoor use would be most important. Arleen Feng noted that the proposal would mostly summarize existing data on stormwater and deliver back the conceptual model to the ECWG. Mike Stenstrom recommended we could develop a mass emissions model and look at atmospheric drop out to see what are the most significant pathways. Arleen Feng responded that atmospheric pathways haven't been explored in great detail and there are no local data but that the project team could include an exercise to list the possible pathways and evaluate each conceptually. Mike Stenstrom agreed and suggested not just a conceptual evaluation but trying to put some rough numbers on the pathways to get an idea of the most important pathways during this first phase of the AFR project.

3d Proposal: Trend Strategy

Aroon Melwani reviewed the work completed to date for developing a trends strategy. We have been working to design a statistical trends model. There's a challenge in designing a sampling program with highly variable PCB data. The model showed that too many samples would be needed to show change over time.

Richard Looker asked what is driving the quality of the model in terms of Guadalupe River (GR) vs Z4LA? Aroon Melwani noted that Z4 concentrations are low and have apparently no spatial signal. For GR there is a signal and there are two different parts of that watershed.

The model development followed this procedure: Develop a multiple linear regression (MLR) model to predict PCB concentrations from grab samples accounting for climatic, seasonal, inter-annual factors [the concentration model]; Apply a regression relationship to continuous records of model variables (turbidity, precipitation) to estimate PCB load per event; Develop MLR model to test for significant changes in event loads over time accounting for climatic, seasonal, inter-annual factors [the trends model] assessing statistical power of MLR for trend scenarios.

A host of predictor variables were investigated in the model and the best models for both Z4LA & GR were evaluated. Residuals were also explored to make sure there weren't other patterns remaining in the data including temporal or seasonal patterns or relationships with other covariates. The residuals were also explored for autocorrelation. The GR findings included turbidity and rainfall parameters that account for significant variation in Guadalupe River PCB concentrations, PCBs predicted as function of turbidity, San Jose rainfall, Loma Prieta rainfall, and season, and the Guadalupe model residuals

indicate normality and homoscedasticity.

The next step was to apply a concentration model to the continuous data to estimate loads and propagate errors. Also, staff needed to determine discrete storm events from the continuous hydrologic record. One-third of the events did not meet the criteria for storm identification. In total 68 storms were selected for inclusion. The model estimated event loads. Events with estimated loads > 100g had higher error bars (~20%).

A trends model was also developed by investigating how various model parameters explain event loads. Residuals were explored which showed no statistical relationship between PCBs and year or season. Residuals of peak flow, SSC and PCB loads over time suggest the model will under predict PCBs at higher SSC. The conclusion of the model is that there have been no trends in PCBs over time of monitoring period.

Mike Stenstrom asked what is the relationship between PCBs and rainfall? Aroon Melwani responded that there's a lot of noise and variability between rainfall and PCB loads and that only a weak relationship exists. Peter Mangarella asked why we didn't do the same analysis with Z4 data? Aroon Melwani responded that initial results looked more promising for GR and with limited funds, we decided to push along with GR to complete a demonstration of concept rather than risking not complete the model for either watershed to a satisfactory level.

Aroon continued his presentation by discussing a power analysis to see what type of pollutant load trends we can detect with different monitoring designs. He superimpose the the empirical data with linear and geometric declines at various rates of change. The data were propagated through trend models procedure to develop new coefficients for the concentration model, estimate PCB event loads and errors (N = 68 storms), and simulate loads and test for trend (using 1000 model runs to generate reliable statistics). The power analysis for PCBs showed no significant annual trends detected in 5% or 10% linear decline and no significant annual trends detected in 4% or 6% geometric decline. For PCBs and Turbidity there was an 80% Power for linear decline of 5% (60% over 12 years) and an 80% Power for geometric decline of 6% (50% over 12 years).

Chris Sommers asked why we would use a geometric vs a linear decline.? Arleen Feng asked what would be the 2nd watershed for the analysis since Z4LA did not show good initial results and didn't have enough data? Bob Hirsch noted that the work has really matured and was very pleased at how the models have developed. He recommended using the geometric trend since it is more realistic e.g. we will never reach zero. Lori Sprague asked if there is an assumption that the decline in PCBs will be based on a reduction in turbidity. Richard Looker said not necessarily but it's uncertain which will be the primary driver (PCBs or turbidity) of a decline. Chris Sommers noted that, if anything, the emphasis should focus on the source control side of the management reduction effort rather than turbidity side which would be more reflective of treatment control. Lori Sprague asked if we are trying to see an overall reduction (induced by uncontrollable variables such as increased stream flow due to climate change) vs a controllable reduction (induced by management action). Richard Looker noted that this is a good point but the TMDL isn't that sophisticated, is prescriptive to a load reduction, but doesn't take into effect other variables that affect loads. Richard Looker hopes that these uncontrollable variables

aren't as important as source reduction. Lester McKee noted that we could explore how the model outputs change if we ramp up rainfall by reasonable amounts as predicted by our published local climate change downscaling simulations. Bob Hirsch noted that it is also important to discuss what types of declines would be seen if there were no changes to rainfall patterns. Lester McKee asked if we need to add some flow normalization. Don Yee noted that the modeled 2017 max is higher than past empirical data - is this an artifact? It was agreed that this would be further explored in the next iterations of the technical work after the meeting.

Trends proposal
Why do we need a regional model?
Lester McKee and Jing Wu presented the proposed work on the trends strategy development. It's very expensive to monitor everywhere so we need a tool that can scale up from individual watersheds to a regional model. The model can also be used to guide future monitoring efforts. The model can also be used to assess management actions. A model is cheap to run once it is developed unlike data collection which has a relatively low information yield that requires a lot of patience to observe all climatic variability - models on the other hand can be used to explore and predict landscape processes outside of observations. Models thus provide continuous management support and a lot of flexibility.

The proposal as it was presented at the meeting would include:
a - Complete Guadalupe trend analysis and design and cost out a field program ($15-20k)
b - Develop a similar statistical model in a second watershed ($50-60k)
c - "Trends level" monitoring ($30k + $70k carryover)
d- Develop a modeling framework for estimating regional scale loads ($75-95k)

Arleen Feng noted that the stormwater program has a Bay Area Hydrology Model - she requested changing the name to distinguish between the models. Chris Sommers asked if we could approve some of the elements and if there is a timing structure and a dependency of the elements? Lester McKee noted that optimally we want to complete 4a before starting 4b, and that 4c would start after 4a and 4b are completed. Phil Trowbridge added that the modeling task is important to figure out where to monitor for trends. Richard Looker asked about synthesizing the trends work in specific watersheds and how to scale that to regional loads to the Bay. It was not clear to him or many others in the room as to why we would spend a significant amount of money on watershed monitoring to plug into developing a regional model. This is a resource allocation question. Lester McKee responded that trends designed for a specific watershed would be used to design a trends monitoring method. Once enacted, the data from applying that method in selected watershed could be used for many purposes including calibration of a model to assist in regional scale loading trend evaluations. Richard Looker asked if the monitoring data could be used for both trends modeling for the regional scale and monitoring trends at the single watershed scale to which Lester and Jing answered yes. Mike Stenstrom said he is skeptical of using a HSPF model as a regional scale model for estimating PCBs loads and asked what mechanisms do we need to better understand before we could calibrate such a model? Arleen Feng noted that the decisions to date about this aspect of the proposal are missing a larger stakeholder input process beyond the STLS monthly meetings and that in this case, the discussion had not been fully completed prior to the SPLWG meeting. If this were to be funded now, the RMP would need to allocate more STLS coordination budget to coordinate more meetings around the development of such a model and

that most permittees are already overloaded. There are a lot of good ideas in this proposal but it's not unrealistic to get this all agreed to by the TRC meeting on June 8th 2017. Chris Sommers added that implementing the model in a parallel fashion with other RAA models might not be the best use of resources and not allow a feedback of information from the RAA model development. Lester McKee summarized the conversation so far by suggesting that there appears to be a consensus emerging to add sub-task 4dii (Refine rationale for watershed archetypes and select watersheds) before 4b (Develop statistical model in 2nd watershed) or at least before 4c to help inform 4c ("Trends level" monitoring).

4 Discussion: Recommended Studies for 2018

Summary of proposals and budgets as presented before discussion.

Proposal #	Proposal Name	Management questions addressed		
			Low End	High End
1a	Advanced reconnaissance data analysis	MQ#3. Management Support	40	60
1b	Reconnaissance characterisation monitoring	MQ #1: Source ID	55	150
2	RWSM support	MQ#4. Loads/ Status/ Presence	5	7
3	AFR conceptual model development	MQ#4. Loads/ Status/ Presence	13	16
4a	Trends strategy: Complete Guadalupe trend analysis	MQ#2. Impairment / MQ#5 Trends	15	20
4b	Trends: Develop a statistical trends model for a 2nd watershed	MQ#2. Impairment / MQ#5 Trends	50	60
4c	Trends: "Trends level" monitoring in a select watershed	MQ#2. Impairment / MQ#5 Trends	30	30
4d	Trends: Develop a regional modeling framework	MQ#2. Impairment / MQ#5 Trends	75	95
5	STLS management support	Coordination and Management	32	32
		Total	**315**	**470**

Kelly Moran was struck by lacking clarity on how the SPL work fits in with the larger issues in the Bay. She recognized that a task/proposal related to connections between SPL and the larger bay issues would not be possible to add this year, it should be considered for next year. She also noted that the SPL is not moving closer to finding true sources - this needs to be a greater focus? She suggested that the proposals are disconnected from where PCBs come from and need an improved connection to source areas. The program keeps trying to connect PCBs to land use without exploring other connections. She suggests we need to look at the conceptual model for PCBs again and think this through some more. There are other linkages such as PCBs in caulk, gas lines etc that need to be

considered in our advanced data analysis proposal. These other sources need to be explored as part of the upstream component in the conceptual model. For the modeling approach to be more effective, it probably needs to be more source specific. Kelly Moran is noting that a source focus could result in better chances of identifying site of management interes. Lester McKee noted that a 2006 report summarized true PCB sources and quantified the source contributions by percentage. We could take another look at that work as a starting point but that source inventory hasn't been revisited since then but BASMAA has been doing some work on this and there are recent published PCB mass inventories that could be used to develop an improved mass balance at the regional scale. Kelly Moran clarified that the work would not need to be done numerically but just needs to be at the conceptual model level (but improved over the 2006 work) summarizing how PCBs in these products would be released in under rainfall-runoff conditions - not quantifying the sources.

Chris Sommers responded that the focus of the STLS is a good point to clarify. There are efforts outside the SPL that aren't often communicated in this venue and that RMP staff are not always aware of the latest information that BASMAA has developed. There's a large effort looking at PCBs in building materials that will be implemented by cities. There's also some effort looking at PCBs in electrical transformers and distribution systems - a white paper. Many of these efforts are data poor. BASMAA could do a better job in communicating these efforts to the RMP staff. Arleen Feng noted that the work BASMAA is doing is beyond monitoring and modeling and is at cross purposes of data needs to some extent. Kelly Moran clarified that her request on the conceptual model is about what needs to be monitored. Phil Trowbridge noted that some of Kelly Moran's request could be incorporated into proposal 1a (advanced reconnaissance data analysis) and that 1a might not be resourced enough to answer some of the questions on data analysis to inform monitoring. Jan O'Hara added some support to Kelly Moran's point. There's a recent lack of documenting the refinements of a conceptual model since we've focused on management. There are one off sources that we don't understand.

Barbara Mahler suggested that the SPL group did discuss looking at true sources at the last meeting (May 2016) but that we all felt it wasn't a fruitful effort due to the lacking information to ID sources.

Peter Mangarella suggested that the trends question is the biggest question and hardest question. Proposal 4a (Guadalupe trends statistical model) and 4b (trends statistical model for a 2nd watershed) relate to evaluating trends based on empirical data in single watershed locations. He then suggested that 4d (Develop a regional modeling framework) says use deterministic modeling to do trends based on presumptions of management actions. He suggested we probably don't want to do both [but his assumption about what 4d is was not correct - 4d is not about estimating trends based on presumptive management actions - this is what RAA modeling will do - instead task 4d is about modeling trends for the region based on input data for single watersheds (let's guess at a half dozen or so) and on real management actions recorded in the accounting system through time that have been completed for the region]. This misconception was near ubiquitous in the room and likely caused by a combination of trying to bring the concept forward to fast and lack of preparation of a full conceptual model prior to the meeting.

Richard Looker noted that the model in 4d could be used for other contaminants. With 4a and 4b you are only getting trend information in the place you are monitoring - not scaling this to regional trends.

Lester McKee noted that Z4LA was dropped in the first trends model development due to resources but we could revisit it if funds were available which might be desirable given its halfway done and what we have learned from Guadalupe and that it represents a nice contrast to Guadalupe - the results of which would provide some idea of the universe of variation for the region as a whole.

Arleen Feng noted that the stormwater manager's question whether funds should be spent on monitoring/modeling or on implementing. Dan Cain asked how much data would be needed to calibrate the proposed 4d model? Jing Wu replied that we have some data to start but it is unclear how much data is needed to support this kind of model. If the “archetype watersheds” are well selected then they can be very representative in the model and thus fewer of them might be needed.

Richard Looker observed that we could look at the proposals on a regrets vs no regrets basis. 1a is no regrets and maybe we increase that budget, 1b, 2, 3, 4a are no regret, 4b is a potential regret, 4c is no regret, 4d is a no regret but many decisions to make before moving forward, 5 is no regret.

Chris Sommers asked if we need to start on a new modeling platform to make a first cut for developing archetypal watersheds for monitoring. He suggested that 4dii (Refine rationale for watershed archetypes and select watersheds) could be done for other reasons outside of preparing for a modeling platform.

Mike Stenstrom noted that we have collected a lot of data that haven’t been adequately analyzed - only a simple ranking method has been used for comparison purposes and much more can be done with the data we have. He suggested that we need to identify collate all the data we have, go through a stakeholder process to define the questions, work with stakeholders to define the modeling needs and the platforms that could be used all before moving forward with developing a model. Modeling is 1% of the cost of data collection but the right model needs to be selected. Peter Mangarella asked why we couldn’t use the RWSM as a model. Jing Wu replied that the RWSM doesn’t have a temporal component and is calibrated at the regional scale not at the scale akin to management practices. Mike Stenstrom countered that we could consider using the RWSM for 4d (regional trends) as long as we are careful to recognize there’s a limit since it is average concentrations and average annual loads. Chris Sommers asked if the RMP staff are ready to make a decision about a modeling platform without the questions Mike Stenstrom raised being answered. Lester responded no - the objective of one of the subtasks to to explore those types of questions and document the rationale for the choice of a suitable modeling platform. Kelly Moran proposed that it would be great if all the counties could combine resources and develop one RAA model. Arleen Feng noted the key question is how to phase this proposed model development in relation to the RAA model developments and that the permittees don’t have the bandwidth to run a parallel modeling effort by permittees and RMP separately. Proposal 4b (Develop a regional modeling framework) needs to be pulled apart and budgeted for each separate subtask but, even then, proposal 5 would need to have more budget to facilitate the stakeholder process even if BASMAA had the bandwidth. Phil Trowbridge reiterated Mike Stenstrom’s idea of building a modeling roadmap as the appropriate task right now - rather than actually getting going on modeling. Chris Sommers reiterated pulling out 4dii (Refine rationale for watershed archetypes and select watersheds) as a first step and not to propose getting started on the modeling just yet until we see the outcomes of some of the county RAA models. Don Yee noted that “archetypal” development

will be an iterative process but that we can start on it and set up a plan for how to do it. He also noted that findings from 1a (Advanced reconnaissance data analysis) will provide further information to support 4dii (Refine rationale for watershed archetypes and select watersheds). Barbara Mahler noted she agrees with the discussion so far and has some discomfort with developing a regional model just yet given all the parallel tracks and projects.

Kelly Moran had a question on the budget in 1b and why it's so variable. Alicia responded that we have some carryover funds and that to some extent, this task just gets all the leftover budget based on the budget cap the TRC provided us - the other tasks need more rigid budgets but the field monitoring task can just be adjusted up or down to do more or less sites depending on available budget.

Peter Mangarella noted that the data resulting from reconnaissance characterization monitoring fieldwork has been useful but there is some concern about the methods both in the field and interpretative - he likes that we are continuing to resolve those and supports task 1a (Advanced reconnaissance data analysis) and 1b (further data collection perhaps with more repeated sites). In terms of trends, 4a is worth doing and maybe 4b but he was not supportive of 4c and 4d. In contrast, Dan Cain was a proponent of trends monitoring and analyses. One outcome of trends monitoring is how to optimize sampling. There's a question on how the data collected in the other tasks will inform a regional modeling effort - need to understand the variability in the data first and the RMP team need to layout the modeling framework more carefully.

Mike Stenstrom also supported the Proposal 1a and 1b (Advanced reconnaissance data analysis and further data collection) but recommended that Aroon Melwani take a look at the existing data to see how many samples you really need to identify watersheds of interest. He recommended that this be done as part of the 1a (advanced reconnaissance data analysis). He supported the continuation to completion of proposal 4a (Trends statistical model development for Guadalupe) but he suggested that we need to check again with the stakeholders on the detection level is for the trend you want to detect. He also supported doing 4b (statistical trends model development for another watershed) and supported the staff recommendation that to do it in Z4LA since we have a start on this one already and that Z4LA represents a different type of watershed and therefore that things will be learned from doing so. He did not support embarking on 4c or 4d at this time but agreed that using some budget to plan out those more carefully would be warranted. Peter Mangarella agreed with Mike that it would be good to get more statistical support for best sampling design for the reconnaissance characterization field methodology - EMC vs grabs and how many storms may be needed to get a reasonable picture of the a realistic EMC for each watershed.

5 Decision: Recommendations for 2018 Special Studies Funding

This is the proposal matrix that resulted after all the discussion at the meeting that was completed during the closed session without RMP staff present.

Proposal #	Proposal Name			
		Low	High	SPLWG

		End	End	Recommendations from 5/17/17
1a	Advanced reconnaissance data analysis	40	60	100
1b	Reconnaissance characterisation monitoring	55	150	150
2	RWSM support	5	7	7
3	AFR conceptual model development	13	16	16
4a	Trends strategy: Complete Guadalupe trend analysis	15	20	20
4b	Trends: Develop a statistical trends model for a 2nd watershed	50	60	30
4c	Trends: "Trends level" monitoring in a select watershed	30	30	0
4d	Trends: Develop a regional modeling framework	75	95	20
5	STLS management support	32	32	32
	Total	**315**	**470**	**375**

Special Study Proposal: Small Tributaries Loading POC Watershed Characterization Reconnaissance Monitoring

Summary: To support a weight-of-evidence approach for the identification and management of PCBs and Hg sources, the outcome of this proposal will be further knowledge about concentrations and particle ratios in stormwater in areas that have a disproportionately larger area of older urban and industrial land use. The proposal is primarily a field study. The level of effort will be tailored to the amount of budget available. There is no phasing proposed.

Estimated Cost: $175k
Oversight Group: STLS/SPLWG
Proposed by: A Gilbreath, J Hunt, J Wu, L McKee and D Yee (SFEI) with oversight from the STLS team (J Scanlin, C Sommers, B DeBerry, L Sabin, L Paquette, R Looker, J O'Hara)

Proposed Deliverables and Timeline

Task	Deliverable	Due date																		
		2018				2019												2020		
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Wet weather field monitoring																				
A	Selected site list	!																		
B	Wet season water samples collected and sent to the labs for analysis		!	!		!		!	!											
C	Laboratory analysis, QA & Data Management									!!										
D	Interpretation & reporting															!				!!

! = STLS check in for review and course corrections
!! = SPLWG oversight and review

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 response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) 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 loads of sediments and trace contaminants 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. These same needs were reflected in the small tributary loading strategy (STLS) (SFEI, 2009). On November 19, 2015 the second MRP was issued and provided an updated set of management questions (provided below) (SFRWQCB, 2015).

During water years (WYs) 2015 - 2018, the RMP funded a watershed characterization reconnaissance study aimed at locating high leverage watersheds and subwatersheds and developing a remote sampler method designed to decrease costs and increase ease of data collection. Over these four years of watershed characterization as well as a similar effort in WY 2011 (McKee et al., 2012), a total of 81 sites have now been characterized for PCB and Hg concentrations and particle ratios during at least one storm (Gilbreath et al., 2017; Gilbreath et al., 2018 in SPLWG review)[1]. In addition, a total of 14 sites have now been characterized using the remote sampler methods (Gilbreath et al., 2018 in SPLWG review; Gilbreath et al., in preparation). Through these efforts, 21 sites for PCBs have been sampled showing highly elevated concentrations (>0.2 ug/g, or 140x the TMDL target), and six sites have been sampled showing highly elevated concentrations for Hg (>1 ug/g, or 5x the TMDL target) (Note: These data only reflect WYs 2011, 2015, 2016 and 2017; results have not yet been returned for sampling in WY 2018). Initial results of the remote sampling pilot indicate that there is a reasonable comparison between the particle concentrations observed from the remote samplers and particle ratios observed in the manual water samples. The additional remote samples completed in WY 2018 are expected to help further resolve the differences observed and provide more nuanced interpretations as well as compare results between the two remote sampler methods.

Study Objectives and Applicable RMP Management Questions

The main study objectives are two-fold:

1. Locate more high-leverage watersheds. Find watershed or subwatershed locations with high particle ratios of PCBs and Hg and rank these locations relative to each other and sources.
2. Develop remote sampling tools. Further test two remote sampler designs (the Hamlin and the Walling tube) for characterization of particle concentrations and comparison to manual methods.

These objectives address management question (MQ) 1 and 2 primarily, and less directly MQ 3 by providing a regional map of concentrations and loads for baseline comparison to the effects of BMP application.

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5: Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

Wet weather field monitoring ($175k)

A wet weather field monitoring program is proposed to continue in the WY 2019 winter season sampling watersheds, subwatersheds or finer scales for management priority. The sampling program will largely mimic the program implemented during WY 2011 (McKee et al., 2012), WY 2015 (McKee et al., 2016), WY 2016 (Gilbreath et al., 2017), WY 2017 (in SPLWG review), and WY 2018 (in preparation) and augmented/altered using the improved sampling methodologies and decision tree for site and storm characteristics developed by the advanced reconnaissance data analysis (in preparation).

- Monitoring Design:

At each site, collect a minimum of:

  - One composite stormwater sample during a rainfall event that is forecast to exceed 0.5 inches of rainfall in a 6-hour period using one of three manual sampling techniques and/or
  - 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 one or both remote sampling techniques (Hamlin or Walling tube).

- Site Selection:
  - Primary selection rationale: Finding new high-leverage watersheds or sub-watershed areas (watershed locations near the Bay margin or further downstream than the source tracking approach).
  - Other selection rationale:
    - Larger watersheds with an existing USGS gauge
    - Re-sampling potential false negatives
    - Contingency for resampling Guadalupe River for trends
    - 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, but likely 13-20 sites.
- The 2018 analytes list will be continued (PCBs, Hg, SSC, TOC, grainsize) in WY 2019

Reporting

The outcome of the study will include a concise technical report. The main objectives of this report will be to 1) document the outcomes of the remote sampler sub-study and make recommendation for its inclusion into future sampling programs; and 2) report and rank concentrations and particle ratios observed at each location and compare these to existing data.

Linkages to other STLS elements

Data collected in this project element is being used to provide useful context for development of the watershed loadings *Trends Strategy*. Data from the watershed characterization reconnaissance study is being used to inform the framework proposed for the necessary baseline data collection to support future trends evaluations.

Linkages to other RMP Workgroups

The PCB WG has allotted funds for WY 2019 to sample in watersheds draining to the Emeryville Crescent and San Leandro Bay (both Priority Margin Units). That study will benefit the POC reconnaissance effort primarily by resampling some watersheds and assessing the variability. Some of the sampling sites chosen for this project may likewise be selected in the watersheds of the Priority Margin Units (PCB WG). Additionally, the emerging contaminants workgroup (ECWG) is proposing a stormwater monitoring study, primarily focused on assessing for roadway contaminants. The ECWG and SPLWG stormwater studies may be able to piggy back on one another where desirable sampling watersheds overlap.

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

Special Study Proposal: Priority Margin Unit Stormwater PCB Monitoring

Summary: This proposed study would yield valuable information on PCB concentrations and particle ratios in stormwater in two Priority Margin Unit (PMU) watersheds. The study areas include the major subwatersheds draining into the Emeryville Crescent, and one subwatershed draining into San Leandro Bay. The subwatershed draining into San Leandro Bay is downstream of a recently remediated hotspot, the former General Electric (GE) transformer and electrical equipment facility, where PCB contamination was severe. The goals of the study are to better estimate current PCB loads into these PMUs (a critical component of the PMU mass budgets) and to support tracking of the effectiveness of the major remediation action on the GE property. Sampling will be completed over two years, as storms allow.

Total Cost: $70k
Funds Requested: $40K
(The PCB Workgroup is recommending that $30k of 2018 funds that had been allocated to Richmond Harbor PMU conceptual model development be redirected to this study.)
Oversight Group: PCBWG in coordination with STLS/SPLWG
Proposed by: A Gilbreath, J Davis and D Yee (SFEI) with oversight from the PCB Workgroup and STLS Team (J O'Hara, J Scanlin, C Sommers, B DeBerry, L Sabin, L Paquette, R Looker).

PROPOSED DELIVERABLES AND TIMELINE

Task A: Identify sampling sites and gain site access (Sept-Oct 2018 and 2019)
Task B: Wet season water samples collected and sent to the labs for analysis (Oct-April 2018-2019 and 2019-2020)
Task C: Laboratory analysis, QA & Data Management (May-Sept 2019 and 2020)
Task D: Interpretation & reporting as a section in a STLS POC Reconnaissance Monitoring Report (Oct-Jan 2020)

Background

During water years (WYs) 2015-2018, the RMP funded a watershed characterization reconnaissance study aimed at locating high leverage watersheds and subwatersheds, and developing a remote sampler method designed to decrease costs and increase ease of data collection. From these four years of watershed characterization as well as a similar previous effort in WY 2011 (McKee et al., 2012), a total of 81 sites have now been characterized for PCB and Hg concentrations and particle ratios during at least one storm (Gilbreath et al., 2017; Gilbreath et al., 2018 in SPLWG review)[1].

Parallel to these POC reconnaissance monitoring efforts, the 2014 update of the RMP PCB Strategy called for a multi-year effort to implement the recommendations of the PCB Synthesis Report (Davis et al. 2014) pertaining to:

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

1. identifying margin units that are high priorities for management and monitoring,
2. development of conceptual models and mass budgets for margin units downstream of watersheds where management actions will occur, and
3. monitoring in these units as a performance measure.

The goal of that effort is to inform the review and possible revision of the PCB TMDL and the reissuance of the Municipal Regional Permit for Stormwater (MRP), both of which are tentatively scheduled to occur in 2020. Conceptual model development for two priority margin units (PMUs; the Emeryville Crescent PMU and the San Leandro Bay PMU) have been completed and model development for a third PMU (the Steinberger Slough PMU) is underway.

PCB loading from stormwater is an important component of the mass budgets for the margin units. To date, some stormwater data has been collected in the PMU watersheds draining to the Emeryville Crescent and San Leandro Bay PMUs, including: Temescal Creek (1 sample), Ettie St. Pump Station (11 samples), Line 12H at Coliseum Way (1 sample). In this study, we propose to augment the stormwater sampling data in these watersheds to improve estimates of loads, obtain stormwater data in the third major watershed draining to the Emeryville Crescent (the Emeryville Crescent North watershed), and obtain data downstream of the major remediation action at GE in support of tracking the effectiveness of that management action.

Study Objectives

The study objectives are two-fold:

1. Collect additional stormwater data in the Emeryville Crescent watersheds. These data will improve stormwater load estimates to the Emeryville Crescent PMU. Additional data collection in the Ettie St. watershed will also help to verify whether it appears concentrations have remained the same since previous sampling (completed in WYs 2008-2011).
2. Collect additional stormwater data downstream of the remediated General Electric remediation site. This data should improve average concentration estimates in this watershed and provide an important baseline to track near-field decreases in PCB loads from the site to the PMU.

These objectives address STLS management questions (MQs) 1, 2, 3 and 4 primarily but also support MQ 5 as possible baseline data for regional stormwater trends assessment.

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5: Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

Wet weather field monitoring

Wet weather field monitoring in the Emeryville Crescent and San Leandro Bay watersheds is proposed as an add-on to the POC Reconnaissance field monitoring program for the WY 2019 and WY 2020 winter seasons. The sampling program will largely mimic the program implemented in these WYs by the reconnaissance monitoring program except will only collect for PCBs and SSC, and no remote samplers will be deployed at these sites. See the POC Reconnaissance monitoring proposal for details of monitoring design.

- Site selection and sampling effort: The PCBWG selected sites at the workgroup meeting. The sites include all three major watersheds draining to the Emeryville Crescent, and one watershed draining to San Leandro Bay. Sites and sampling effort are shown below. The goal is to have a total of 3 to 4 storms of monitoring data at all sites. Only 2 to 3 storms are recommended at Temescal Creek and Line 12H because each of those watersheds were already sampled once either in WY 2017 or WY 2018. The total number of sites/storms that can be sampled is dependent on number of false starts and number of times that multiple sites can be sampled by the same team in the same storm event.

Site	Number of Storms
Ettie St. Pump Station	3-4
Temescal Creek	2-3
Emeryville Crescent North	3-4
Line 12H at Coliseum Way (downstream of the General Electric property)	2-3

- Analyte list: The analyte list will PCBs (209 congeners) and SSC.

Budget

Line Item	**Cost**
Sample Collection and Analysis for Emeryville Crescent Sites	$55,000
Sample Collection and Analysis for San Leandro Bay Site	$15,000
Data Management	NA – covered by STLS POC Monitoring
Reporting	NA – covered by STLS POC Monitoring
Total	$70,000
Funds Already Allocated[1]	$30,000
Funds Requested	$40,000

[1.] 2018 funds allocated to Richmond Harbor Conceptual Model. PCBWG recommends postponing that task and re-allocating those funds to this project.

Reporting

The outcome of the study will include a concise technical report that may be stand-alone or included in the POC Reconnaissance Report. The main objectives of this report will be to 1) report and rank concentrations and particle ratios observed at each location and compare these to existing data, and 2) estimate loads for each watershed sampled.

Linkages to other RMP Workgroups

The PCBWG is recommending allotment of funds for WY 2019 to sample in watersheds draining to the Emeryville Crescent and San Leandro Bay. This study will benefit the POC reconnaissance effort primarily by resampling some watersheds and assessing variability. Some of the sampling sites chosen for the SPLWG POC reconnaissance project may likewise be selected in the watersheds of the Priority Margin Units (other watersheds and/or other Priority Margin Units (PCBWG)).

References

Gilbreath, A.N., Hunt, J.A., Yee, D., and McKee, L.J., 2017. Pollutants of concern (POC) reconnaissance monitoring final progress report, water years (WYs) 2015 ad 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, California.

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Special Study Proposal: Advanced Data Analysis, Phase II

Summary: Reconnaissance data collected during single storms have provided good evidence to support enhanced management effort in watersheds with high PCB concentrations in water and on sediment particles. However, to date, such data have had more limited value for prioritization of management effort in watersheds exhibiting moderate or lower concentrations. This project proposes to enact the second phase of development and application of enhanced ranking and fingerprinting methods for the spatial prioritization and identification of watersheds, sub-watersheds, and PCBs source areas. The outcome of this proposal will be a finalized stepwise methodology and application of that methodology to existing stormwater datasets to help prioritize areas for enhanced management or further sampling.

Estimated cost total: $50k
Oversight Group: STLS/SPLWG
Proposed by: L McKee, A Gilbreath, J Hunt, J Wu, J Davis, and D Yee (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Task	Deliverable	2019											
		J	F	M	A	M	J	J	A	S	O	N	D
A	Completed refined methodology for identifying and ranking watersheds in relation to each other	!	!	!									
B	Completed refined methodology for identifying and ranking subwatersheds of importance within a larger watershed based on PCB fingerprinting	!	!	!									
C	Completed refined methodology for prioritizing source areas of importance within a larger watershed based on PCB fingerprinting	!	!	!									
D	Draft and final report					!!		!		!	!!		

! = STLS check in for review and course corrections
!! = SPLWG oversight and review

Background

During water years (WYs) 2011, 2015, 2016, 2017, and 2018, the RMP funded a stormwater characterization reconnaissance study aimed at locating high leverage watersheds and subwatersheds for management focus. Over these five years, a total of 81 sites have been characterized during at least one storm for PCB and Hg concentrations and particle ratios (the ratio of a pollutant concentration measured in a stormwater sample to the suspended sediment concentration in that same sample) (McKee et al., 2012; Gilbreath et al., 2018 in SPLWG review; Gilbreath et al., in preparation). These data build upon and complement data derived from a more detailed sampling program that was carried out at eight locations where samples were taken during multiple storms over two or more years (WYs 2003-2010, 2012-2014) (Gilbreath et al., 2015; McKee et al., 2015).

Although taking a single storm composite sample has a relatively low cost compared to taking multiple discrete samples a storm during many storms, differing storm characteristics (intensity, duration, antecedent rainfall conditions) interplay with differing suspended sediment erosion and PCB source characteristics to confound comparisons between watersheds. Yet, to date, the

primary method of interpretation has been one of simple ranking using two methods, directly measured PCB or Hg concentrations, and the ratio of concentrations of PCBs or Hg in the stormwater sample to the suspended sediment concentrations in the same sample. The most recent report (Gilbreath et al., 2018) ranked 79 sites from highest to lowest based on these two simple methods. This method, coupled with other evidence including land use and source area characteristics, property surveys, and soil sampling, has taken us a long way towards identifying a number of small industrial watersheds of management interest when concentrations are high. But is has been less well-suited to providing evidence and a rationale for how to prioritize management in watersheds exhibiting moderate or lower concentrations. However, it is recognized that there may be sources of interest in these watersheds also. There are a few main reasons for the limited success in providing useful information across a broad range of concentration and watershed types.

1. Concentrations and particle ratios are indirect indicators of the real metric of interest (mass load).
2. The current ranking method has no adjustment for the dilution that occurs in mixed land use watersheds when stormwater and sediment derived from “cleaner” areas mixes with contaminated water mainly from industrial areas and PCB and Hg source properties. This dilution varies from watershed to watershed depending on the land use configuration but it is easy to conceive dilution factors as low as 2:1 and as high as 10:1.
3. There is no consideration of the PCB congener distribution (fingerprint) that may provide additional information about source types upstream or provide useful forensic evidence of the contribution of similarly fingerprinted water samples collected upstream in nested subwatersheds or similarly fingerprinted sediment and soil samples collected upstream adjacent to suspected source properties.
4. The current ranking method does not consider storm characteristics (e.g., rainfall intensity, antecedent rainfall) during the sampling periods.

Recognizing these weaknesses, the Sources Pathways and Loading Workgroup of the RMP recommended an advanced data analysis project. The project aims to mine and analyze existing stormwater and storm drain infrastructure sediment data with the primary goals of developing an improved method for identifying and ranking watersheds, sub-watersheds, and potential PCBs source areas of management interest for further screening or investigation, and guiding future sampling design. The RMP-funded project is underway in the first half of 2018. The following outcomes of the 2018 project are expected.

1. The completion of version 1 of a new watershed intercomparison method for ranking based on mass, completion of the documentation of how to apply the method, and pilot demonstration of the method to a subset of sites (about a dozen). This new method is expected to provide a more accurate evaluation of relative contamination between sampling locations and will incorporate an uncertainty analysis and include statistical approaches such as Partial Least Square Regression and Random Forests Model to identify the most influential predictor variables for PCB concentrations and loads using a staged approach. The first stage is to explore the relationship between the rainfall variables and dependent variables at each watershed. The second stage is to investigate the groups of watersheds that were sampled during the same weather events to test the impact of landscape and source variables to help define critical land areas of interest.

2. The development of two PCB profile recognition methods (one based on indicator congeners and the second on other congener profiles) and application in the Guadalupe River watershed to:
    a. relate stormwater data collected in a nested fashion to downstream stormwater samples (sub-catchment scale)
    b. relate sediment and soils data collected near potential source properties to downstream stormwater samples

This proposal is for a second year of funding to continue to build these promising techniques.

Study Objectives and Applicable RMP Management Questions

The main study objective is complete and apply improved methods for the spatial prioritization of areas for enhanced management interest. The methods are being developed and tested at a variety of scales relevant to management:

i) Watershed scale
ii) Nested subwatershed scale
iii) Source property scale

The outcomes are expected to support improved decision making about how to use limited resources for further investigations. Such investigations might include the initiation of enhanced sampling programs by BASMAA agencies to further characterize and identify source properties, and further stormwater reconnaissance characterization sampling by the RMP or BASMAA to verify or refute the need for enhanced focus.

These objectives address management question (MQ) 1, 2, 3 and 4 primarily.

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?

MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?

MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.

MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.

MRP 2.0 Q5: Trends: What are the temporal trends in loads or concentrations?

Approach

Given the large variation in data available at each scale of management interest, improved methods were developed at a variety of scales.

A. For watersheds where there are suspected sources but where there are no stormwater data in subwatersheds (tributary locations) and no or limited data on soils and sediment concentrations adjacent to potential source properties, data can be collected at the outlet of the watershed and used (along with land use and source area maps and other local evidence) to determine importance relative to other watersheds. This watershed-scale screening has been going on for years but

the current simple ranking methods need refinement. The approach taken for refinement at this scale uses three types of evidence.

a. Estimation of mass transport during a standard storm size. To do this, we have developed a mathematical adjustment methodology based on evaluation of data collected at the eight well-sampled watersheds and made estimates of flow for each measured storm.

b. Improved evaluation of land uses and source areas of interest for area normalization (to do this we used two methods - (1) the land use and source areas used in the RWSM and (2) we have explored a stepwise statistical evaluation of land use and source areas)

c. the use of congener patterns for recognizing watersheds of management interest

In Phase I of the project (CY 2018) we developed beta versions of these methods for a subset of watersheds. In this, Phase II of the project, further refinement and application to the larger dataset will be completed.

B. For a smaller number of watersheds where stormwater samples have been collected in a nested fashion, a congener and homolog fingerprint methodology was piloted in CY 2018 for just one watershed (Guadalupe). In this, Phase II of development, the chosen method will be refined and applied to additional watersheds in the Bay Area where nested data are available. The outcome will be an improved basis for prioritization of sub-catchments of management interest.

C. For a small group of source properties where sediment and soils data have been collected in adjacent public right of ways, a congener and homolog fingerprint methodology was piloted in CY 2018 for source properties in just one watershed (Guadalupe) using only recently collected (2013/2013 and later) sediment and soils data. In Phase II, the chosen method will be refined and applied to additional watersheds in the Bay Area where data adjacent to potential source properties are available. This may include exploring the use of older sediment and soils data for which there are congener data available (the ~600 data points collected prior to 2010). The outcome will be an improved basis for prioritization of potential source properties of management interest.

D. The last task is to complete documentation that will include a stepwise methods for each management scale so that others can apply the methods themselves.

Reporting

Outputs (Deliverables):

A technical report that provides the technical justification for the methods recommended and outlines in a stepwise fashion how to apply the methods to other Bay Area data sets. The draft will be presented in May and the final by November 2019.

Linkages to other STLS elements

Data collected in this project may provide enhanced methods for interpreting data that may be input for RAA, could be used to refine the calibration of the RWSM, and may provide useful context for development of the watershed loadings *Trends Strategy*.

References

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McKee, L.J. Gilbreath, N., Hunt, J.A., Wu, J., and Yee, D., 2015. Sources, Pathways and Loadings: Multi-Year Synthesis with a Focus on PCBs and Hg. 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). SFEI Contribution No. 773. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/sites/default/files/biblio_files/MYSR%20Final%20Report.pdf

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Special Study Proposal: STLS Regional model development to support trends strategy

Summary: The draft STLS Trends Strategy outlines a process to answer the key management question of how loads of pollutants of concern (e.g., PCBs) are changing over time. Progress has been made in trend analysis for individual watersheds with the RMP study of PCB loads in the Guadalupe River as well as BASMAA's interim accounting tool for tracking management efforts. However, questions remain as how the loads at the regional scale have and will change as a result of decadal long management actions and in relation to TMDL goals. The draft STLS Trends Strategy identified this question as a priority and developed a plan to obtain initial answers by 2021. This proposal is for funding in 2019 to implement the first year of this plan. The tasks to be completed are: (1) to develop a detailed Modeling Implementation Plan and then (2) to develop a regional model for hydrology and suspended sediment. The hydrology and sediment model, once established, will be used as basis for Pollutants of Concern (POC) modeling in the subsequent years.

Estimated Cost: $100,000
Oversight Group: STLS/SPLWG
Proposed by: Jing Wu, Lester McKee, Don Yee, Alicia Gilbreath, and Jennifer Hunt (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Task	Deliverable	Due Date																	
		2019												2020					
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
A	Modeling Implementation Plan	!		!		!!													
B	Regional Model Development							!		!		!		!		!		!!	

! = STLS check in for review and course corrections
!! = SPLWG oversight and review

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, Municipal Regional Permit for Stormwater (MRP) ((SFRWQCB 2009, SFRWQCB 2015) called for the implementation of control measures to reduce PCB and Hg loads from smaller urbanized tributaries, and also provided a set of management questions (MQs) that has been used as the guiding principle for the region's stormwater related activities.

> MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
>
> MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?
>
> MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
>
> MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.

MRP 2.0 Q5: Trends: What are the temporal trends in loads or concentrations?

Over the past decade, considerable effort, including both field monitoring and empirical data collection and modeling, has been taken by both RMP and BASMAA to address these management questions. These effort has mostly focused on addressing MQ 1, 2, and 4.

In recognizing the need to answer MQ5 regarding how POC loads or concentrations from small tributaries has changed over time, a STLS Trends Strategy was developed in 2016 and subsequently updated in 2018 to outline a process to answer the key management question of how loads of pollutants of concern (e.g., PCBs) are changing over time. Progress has been made in trend analysis for individual watersheds with the RMP study of PCB loads in the Guadalupe River as well as BASMAA's interim accounting tool for tracking management efforts. However, questions remain as to how the loads at the regional scale have and will change as a result of decadal long management actions and in relation to TMDL goals. The draft STLS Trends Strategy identified this question as a priority and developed a plan to obtain initial answers by 2021. This proposal is for funding in 2019 to implement the first year of this plan.

Study Objectives and Applicable RMP Management Questions

The objectives of this study are to 1) develop a modeling implementation plan that will be used to guide regional model development; and 2) embark on the first phase of model development for hydrology and suspended sediment loads to provide a basis for POC modeling and set the stage for trends evaluation.

This study addresses management question 5 primarily but also directly supports MQ 1, 2, and 4 by providing concentration and load information for all watersheds in the region. The regional model also provides a mechanism for evaluating management actions that is call upon in MQ 3.

Approach

Task A. Develop a Modeling Implementation Plan to guide a regional modeling effort

At a STLS meeting in April 2018, it was decided that the initial effort will be focused on understanding the trends in loads at small tributary locations at the regional scale. A regional watershed model is needed to accomplish this goal. Therefore, this task will develop a detailed Modeling Implementation Plan with the following information:

- Recommended modeling platform
- Model assumptions, processes represented, and calculation procedures
- Model input data and their data sources or other assumptions
- Calibration and verification processes and acceptance criteria
- Geographic scale for modeled watersheds
- Temporal scales for the model (e.g., period of model simulation and time step)
- Procedures for reporting model outputs
- Monitoring Design for hydrology, suspended sediment, PCBs, and other parameters needed to sufficiently calibrate and verify the model
- Monitoring Data Gap Analysis based on a comparison of current monitoring programs to the recommended monitoring design.

The Modeling Implementation Plan will be developed with input and oversight by STLS and the SPLWG before actual modeling work begins.

Task B. Develop a regional watershed model for POC trends evaluation
After approval of the Modeling Implementation Plan, a phased approach will be employed to develop the regional model, starting with hydrology, followed by suspended sediment, and then POCs. This task represents the first phase of the model development and will cover hydrology and suspended sediment only. Below is a standard model application process that will likely be followed pending approval of the Model Implementation Plan:

- Collect and process model input data and monitoring data (for calibration).
- Calibrate the model to observed data
- Process and interpret model outputs for load estimates and trends evaluation at regional and watershed scales

Budget

Task	Budget
A. Develop a modeling implementation plan to guide regional modeling effort	$25,000
B. Develop a regional watershed model for POC trends evaluation	$75,000
Total	$100,000

<u>Budget Justification</u>

Labor Costs
Task A: 150 hours (~4 weeks) of modeler time to prepare the Modeling Implementation Plan. This time includes preparing draft plan and responding to comments.

Task B: 100 hours of technician time to gather and format input data. 390 hours of modeler time to set up the model, perform calibrations/verifications, and prepare the Model Development Report.

Reporting
Task A: The Modeling Implementation Plan will be presented as a technical report. The plan will be completed as a draft for SPLWG review in May 2019, and finalized in July 2019 after the review and approval from STLS.

Task B: Regional model development will begin after the Modeling Implementation Plan is approved. A Model Development Report will be prepared as a draft for SPLWG by May 2020 and finalized by June 2020.

Linkage to other STLS Proposed Tasks
The data collected from wet weather monitoring will be used to support the initial development of the regional model. The monitoring design outlined in the Modeling Implementation Plan can be used to guide future monitoring efforts.

Linkages to other RMP Workgroups

Sediment has emerged as a pollutant targeted for research and management actions. The Sediment WG has identified estimating sediment loads from Bay area watersheds as one of research needs. The regional model could be used as a platform to estimate sediment loads. The Emerging Contaminants Workgroup (ECWG) has developed a Contaminants of Emerging Concern (CECs) strategy that identifies stormwater as a significant pathway for many CECs and calls for a combined modeling and monitoring approach to estimate their loads. Similar to sediment, the regional model can be utilized to estimate stormwater CECs loads from small tributaries to the Bay.

References

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. 279pp. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/index.shtml

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Special Study Proposal: Contaminants of Emerging Concern (CECs) in Urban Stormwater

Summary: Preliminary results from a 2016 RMP Special Study that scanned Bay water samples for contaminants via non-targeted analysis suggest that stormwater has the potential to contain significant levels of potentially harmful contaminants. An independent effort to probe stormwater-related Coho salmon aquatic toxicity in the Puget Sound region has led to development of a targeted list of key CECs in urban stormwater, which includes contaminants derived from sources such as vehicle tires and urban use pesticides. As part of a West Coast screening effort using this new, targeted analyte list, we propose analyzing stormwater samples collected from urban watersheds discharging to San Francisco Bay.

Three additional classes of emerging contaminants were identified in recent RMP reports and ECWG discussions as critical stormwater data needs: per- and polyfluoroalkyl substances (PFASs), phosphate flame retardants, and ethoxylated surfactants. A two-year study is proposed to provide an intensive and pioneering examination of CECs in urban stormwater. The first year would include site selection and pilot sample collection and analysis for all four CEC classes, and the second year would focus on collecting a greater number of samples for this Bay Area-wide screening study.

Estimated Cost: $395,000 (Year 1 $100,000; Year 2 $295,000)
Oversight Group: ECWG and SPLWG
Proposed by: Rebecca Sutton (SFEI), Ed Kolodziej (University of Washington), Chris Higgins (Colorado School of Mines), Da Chen (Jinan University), Lee Ferguson (Duke University)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Site selection and reconnaissance, in coordination with SFEI stormwater and STLS teams; development of sampling protocol	Summer 2018
Task 2. Pilot field collection of stormwater samples	Fall – Winter 2018
Task 3. Laboratory analysis of pilot samples; review of data to improve protocols and analytical methods	Spring 2019
Task 4. Site selection and reconnaissance, in coordination with SFEI stormwater and STLS teams; dissemination of sampling protocols to partners recruited to assist in sample collection	Summer 2019
Task 5. Field collection of stormwater samples	Fall 2019 – Spring 2020
Task 6. Laboratory analysis of samples	Summer 2020
Task 7. Review and analysis of data	Fall – Winter 2020
Task 8. Draft manuscripts and summary for managers for ECWG meeting	Spring 2021
Task 9. Final manuscripts and summary for managers	Fall 2021

Background

An important element of the RMP's CEC Strategy is the application of non-targeted methods to identify unexpected contaminants that merit further monitoring (Sutton et al. 2017). In 2016, the RMP funded a special study to use a type of non-targeted analysis to examine Bay water samples collected from three sites influenced by three different pathways: effluent, stormwater, and agricultural runoff.

Preliminary findings from this study, presented at both the ECWG meeting (Ferguson et al. 2017) and the RMP Annual Meeting (Sun et al. 2017) last year, indicate that water samples from the stormwater-influenced site, San Leandro Bay, contained a broad array of unique contaminants with strong signals suggesting higher concentrations. Contaminants identified with high confidence include 1,3-diphenylguanidine (DPG), a rubber vulcanization agent derived from vehicle tires, as well as ε-caprolactam, used to make the nylon polymers found in tires and many other products. The European Chemicals Agency has established predicted no effect concentrations (PNEC) for DPG of 30 μg/L in freshwater and 3 μg/L in marine waters (ECHA 2018). While the non-targeted analysis provides only qualitative data, the high relative strength of the DPG signal in San Leandro Bay suggests that this contaminant has the potential to be present at concentrations similar to these PNECs.

These findings indicate that stormwater is a pathway by which unique contaminants from vehicles and roadways make their way to tributaries and near-shore Bay environments. An additional factor contributing to a special interest in emerging contaminants from stormwater is that, unlike wastewater, this pathway generally receives no treatment. As a result, limited degradation or trapping of contaminants occurs prior to their discharge to the Bay. Furthermore, CEC investigations to date in the RMP and elsewhere have focused primarily on wastewater, and CECs in stormwater have received relatively little attention.

Stormwater-derived contaminants have been an especially high concern and research focus in the Puget Sound region, where adult Coho salmon (*Oncorhynchus kisutch*) in Puget Sound streams experience acute toxicity via pre-spawn mortality following exposure to urban runoff (Du et al. 2017). This response is not correlated with conventional water chemistry parameters including temperature, dissolved oxygen, and suspended solids; disease; spawner conditions; or exposure to monitored pesticides, metals, or polycyclic aromatic hydrocarbons (Scholz et al. 2011).

In an effort to identify the potential cause of this acute toxicity in the Puget Sound area, non-targeted analysis of stormwater and tissues from runoff-exposed fish has resulted in the identification of a number of unique contaminants with sources specific to vehicle traffic. One example is hexa(methoxymethyl)melamine (HMMM), a component of tire resin, which can occur in highway runoff at concentrations exceeding 10 μg/L (Kolodziej, unpublished data). More recent research indicates that aqueous leachates from automobile tires can induce acute toxicity in Coho salmon, leading to a focus on understanding the risks of this pollutant source to salmonids and other aquatic organisms. In addition to the acute effects, related ecotoxicology research suggests that stormwater exposure can induce altered growth, decreased immune function, impaired lateral line development, and cardiotoxicity in salmonids (McIntyre et al. 2016; Young et al. 2018), suggesting that a suite of adverse

sublethal impacts derived from stormwater exposures are important aspects of water quality in urbanized areas.

A direct outcome from these non-targeted analytical efforts was the development, by Dr. Kolodziej, of a list of target analytes to assess the stormwater pathway as major contaminant inputs. While there are a number of targeted CEC lists designed around the influence of wastewater (e.g., focused on pharmaceuticals and other compounds typically disposed of down the drain), this is the first major effort to develop a CEC list targeting the influence of urban runoff in aquatic habitats with a concerted analytical effort.

The RMP has the opportunity to take part in a West Coast-wide screening effort, analyzing Bay Area stormwater using this new list of targeted CECs derived from vehicular sources, urban use pesticides, and other ubiquitous urban contaminants. While the endangered Coho salmon, the focus of the Puget Sound research effort, are now absent from tributaries discharging to the Bay, steelhead (*Oncorhynchus mykiss*), a threatened species, are observed in some Bay streams (e.g., Guadalupe River, Alameda Creek).

In addition to this newly developed list of urban stormwater CECs, three more classes of emerging contaminants have been identified in recent RMP documents and ECWG discussion as critical data gaps for stormwater.

<u>Per- and polyfluoroalkyl substances (PFASs)</u> – PFOS, PFOA, and other long-chain perfluorocarboxylates are classified as Moderate Concerns for the Bay, while other PFASs are considered Possible Concerns. A conceptual model of sources of PFASs to stormwater includes outdoor textiles, plastic items, paints, and urban litter (e.g., food packaging), as well as industrial products such as fire-fighting foams. Atmospheric deposition is also possible. The RMP's draft PFAS Synthesis and Strategy (Sedlak et al. 2017) reviewed two studies of stormwater that have been conducted in the Bay Area: a seven site study conducted in Water Year 2010, and a 10 site study conducted in Water Year 2011. A relatively small number of PFASs were monitored; in addition, the watersheds monitored were not specifically selected to provide representative data for these contaminants in the Bay Area. The PFAS Synthesis and Strategy recommends stormwater monitoring as an RMP priority for future work.

<u>Phosphate flame retardants</u> – At present, alternative flame retardants are generally considered Possible Concerns for San Francisco Bay. A conceptual model of sources of these contaminants to stormwater includes outdoor products such as construction and building materials, as well as volatilization from a far broader assortment of consumer goods to the air followed by deposition to urban streams. Samples collected during two storms (Water Year 2014) at two Bay Area stormwater sites indicate the presence of phosphate flame retardants at concentrations generally comparable to those found in wastewater (Sutton et al. in prep). A draft RMP report that reviews available data for this class of CECs recommends stormwater monitoring as a priority for the RMP (Lin and Sutton 2018).

<u>Ethoxylated surfactants</u> – Ethoxylated surfactants include alkylphenol ethoxylates (classified as Moderate Concerns for the Bay), as well as alcohol ethoxylates and others. A conceptual model of sources of ethoxylated surfactants to stormwater includes outdoor use and automotive cleaners, lubricants and other fluids, as well as pesticides, plastics, paints, and many other products. The non-targeted analysis of San Francisco Bay sites described

previously also identified a number of ethoxylated surfactants at with strong signals in the stormwater-influenced site, San Leandro Bay (Ferguson et al. 2017; Sun et al. 2017).

At the spring ECWG meeting (April 12-13, 2018), stakeholders and experts expressed strong support for a broad screening of stormwater for all four groups of CECs mentioned above.

Study Objectives and Applicable RMP Management Questions

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

Management Question	Study Objective	Example Information Application
1) Which CECs have the potential to adversely impact beneficial uses in San Francisco Bay?	Compare new occurrence data for stormwater CECs with toxicity information reported in the scientific literature. Evaluate future monitoring needs and toxicity data gaps.	Do any stormwater CECs merit additional monitoring in the Bay or a specific classification in the tiered risk framework? What are the potential risks of these CECs? Is a need for management actions indicated?
2) What are the sources, pathways and loadings leading to the presence of individual CECs or groups of CECs in the Bay?	Compare concentrations observed at different sites in the Bay Area to glean possible insights regarding the influence of sources or land use types. Compare Bay Area concentrations to other measurements of other urban areas.	What are the key sources or land uses that are associated with idividual CECs or CEC classes in stormwater?
3) What are the physical, chemical, and biological processes that may affect the transport and fate of individual CECs or groups of CECs in the Bay?	N/A	
4) Have the concentrations of individual CECs or groups of CECs increased or decreased in the Bay?	Compare concentrations with previous monitoring data for a limited number of analytes.	The data from this study can establish baseline data for stormwater CECs in the Bay Area. Instructive comparisons are possible for a subset of analytes previously examined in Bay Area stormwater, though robust trends cannot be inferred due to data limitations.
5) Are the concentrations of individual CECs or groups of CECs predicted to increase or decrease in the future?	N/A	
6) What are the effects of management actions?	N/A	

Approach

Stormwater Sample Collection

For this screening effort, two phases are recommended. Pilot sample collection will occur in fall and winter of 2018, and a larger monitoring effort, supplemented with field work by stakeholder partners, will occur fall through spring of 2019/2020.

Site selection will occur prior to each of these sample collection campaigns, in consultation with the stormwater loading team at SFEI, the RMP's Small Tributaries Loading Strategy (STLS) team, and the California Department of Pesticide Regulation (DPR). Sites will be selected based on multiple factors including: 1) greater relative urban land use in the watershed, with an emphasis on proximity to roadways; 2) unique land uses associated with potential contaminant sources, such as airports; and 3) reduced sample collection costs due to existing sample collection underway as part of other studies. Site selection will be informed by the conceptual models of potential sources of the CECs to stormwater, with sites located in proximity to these sources being of particular interest.

During pilot sample collection, 10-20 samples (including field blank and duplicate samples) will be collected. Samples will consist of grabs or composites collected into pre-cleaned amber glass containers. Composites collected using an ISCO pump during the rising hydrograph of a storm are preferred for use with the new stormwater CECs analyte list developed by Dr. Kolodziej. For the other types of contaminants, use of the ISCO pump may lead to procedural contamination. For these contaminants, one or more grab samples will be collected at each site, and may be combined in the analytical laboratory to produce a composite.

Particular focus will be placed on capturing the first fall flush at one or more sites of interest, with storm size criteria to be developed in consultation with STLS and RMP experts. At least one site will be revisited during a later storm as an initial means of assessing variability. QA/QC samples collected will include at least one field duplicate and one field blank. A greater number of samples (e.g., 20) will be collected during the pilot phase if a number of storms pass through the region, in case sample collection proves difficult during the next phase due to fewer storms.

Review of preliminary data from this pilot effort and further consultation with local stormwater experts in 2019 will support refined sample collection protocols and site selection for the larger monitoring effort to occur fall 2019 – spring 2020. This more comprehensive sample collection effort is expected to produce 30-40 samples (including field blank and duplicate samples), in part through in-kind assistance from interested stormwater agencies and the leveraging of existing monitoring activities by the RMP and agencies such as DPR. Training and equipment will be provided to these sample collection partners.

Chemical Analysis

A total of 50 stormwater samples (including field duplicates and field blanks) will be characterized over two years for four sets of CECs, by four different academic laboratories with specialized expertise.

Stormwater CECs: Unfiltered samples will be analyzed by the Kolodziej laboratory (University of Washington) with a newly developed, targeted analytical method using multi-residue solid phase extraction (SPE) and liquid chromatography with tandem mass spectroscopy (LC-MS/MS). Approximately 35 compounds will be monitored, including pharmaceuticals, pesticides, and several vehicle-specific analytes such as DPG and HMMM. A description of the analytes is provided as a separate attachment. This suite of representative tracers for urban runoff includes a broad range of contaminants with different physical-chemical parameters (e.g., various chemical functionalities, wide range of polarities and biodegradation potential). The compounds were selected to represent three primary urban sources: residential use, roadways, and wastewater.

PFASs: Unfiltered samples will be analyzed by the Higgins laboratory (Colorado School of Mines) using quadrupole time-of-flight mass spectrometry (LC-Q-ToF-MS). The samples will be extracted and cleaned up using established protocols for the analysis of PFASs in soils and sediments (McGuire et al. 2014; Barzen-Hanson et al. 2017). Each sample will be split, with one aliquot being subjected to the TOP assay (oxidation followed by LC-QToF-MS; Houtz and Sedlak, 2012) and the other aliquot being directly analyzed by LC-QToF-MS. The stormwater extracts will be injected and separated on a C18 column prior to analysis by both ESI+ and ESI- LC-QToF-MS. Quantitative analysis will be performed on 45 PFASs, including different perfluoroalkanoic acids, perfluoroalkane sulfonates, perfluoroalkane sulfonamides, fluorotelomer sulfonates, and fluorotelomer alkanoic acids. This list includes PFASs on the UCMR3 list along with many others.

Phosphate Flame Retardants: Both dissolved and particulate phase samples will be analyzed by the Chen laboratory of Jinan University. Samples will be extracted in the U.S. by a partner laboratory, then shipped to China, where Dr. Chen will characterize contaminants within the aqueous and solid phases using highly sensitive liquid chromatography–triple quadrupole mass spectrometry (LC-QQQ-MS/MS) based analysis methods (Chen et al. 2012; Chu et al. 2011). Limits of detection are typically in the range of 0.1 ppb. Dr. Chen has agreed to undertake method development to add recently identified phosphate flame retardants, including isopropylated and tert-butylated triarylphosphate esters (ITPs and TBPPs; Phillips et al. 2017), to his extensive list of target analytes.

Ethoxylated Surfactants: Stormwater samples will be analyzed for ethoxylated surfactants by the Ferguson laboratory of Duke University, using a method to be developed. The matrix is likely to be total water, and the analyte list is expected to include the following surfactant families: nonylphenol ethoxylates, octylphenol ethoxylates, and C12, C14, and C16 alcohol ethoxylates. Analytes for each family will include compounds with a broad range of ethoxylate chains. Isotopically labeled standards are only available for a few of these analytes; however, the uncertainty associated with quantitation was deemed acceptable by the ECWG for screening purposes.

Data Interpretation

We anticipate most of these contaminants will be widely observed in urban areas but have lower concentrations in non-urban areas. Therefore, the screening data will be evaluated based on land use type. Specific indicators of source types, such as road density, will be used for an initial investigation into key sources or land uses associated with these CECs.

Results for the Bay Area will also be compared to levels observed in other urban regions. In particular, Dr. Kolodziej is coordinating a West Coast wide sampling effort, which is likely to include southern California, the Portland area, and the Seattle/Puget Sound area.

Levels in Bay Area stormwater will also be compared to available toxicity thresholds. Findings may highlight concerns, data gaps, and the need for further research.

Budget

Budget Justification

Planning and Stakeholder Engagement Costs
In consultation with RMP and STLS stormwater experts, we will establish a study design that includes site selection criteria, a prioritized list of potential sites, and storm criteria. Pilot study design established in advance of the pilot sampling effort is likely to be refined prior to the second phase of sampling, based on experience in the field and initial laboratory analyses. Study design discussions and preliminary data reports will require regular participation in monthly calls with the STLS team.

Stormwater agencies will be recruited to provide in-kind assistance through sample collection during the second wet season, to establish a more comprehensive and representative dataset for this initial screening. Training and equipment will be provided to assure sample collection goes smoothly. At the conclusion of the study, SFEI staff will craft a presentation of findings for stormwater agencies.

Field Costs
This special study proposal includes up to $92,000 devoted to stormwater sample collection (site selection and reconnaissance, permit applications, development of sample collection protocols, and field work). Sample collection will occur over two wet seasons.

Every effort will be made to minimize field costs through leveraging existing stormwater monitoring activities of the RMP and the California Department of Pesticide Regulation (DPR). DPR plans to monitor three Bay Area stormwater sites for pesticides, and may be able to collect stormwater samples for RMP studies.

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

Analysis and Reporting Costs
Preliminary results will be reported to and reviewed by ECWG, STLS, and SPLWG. Preparation of draft manuscripts for publication in a peer-reviewed journal (stormwater-themed special issue) would generally be led by the analytical partners; RMP scientists may be lead authors of one of the manuscripts, and coauthors of others. After the manuscripts are complete, RMP staff will produce a summary document for managers that describes the results and their implications for stakeholders.

Laboratory Costs
Each laboratory is receiving a budget sufficient to refine method development and analyze 50 samples. Laboratory QA/QC samples will be analyzed at no charge, while field blanks and field duplicates will be considered part of the 50 samples charged to the RMP.

Table 2. 2019 CECs in Stormwater budget

Expense	Estimated Hours	Estimated Cost
Labor - Year 1		
Study Design, Stakeholder Engagement	130	18,000
Stormwater Sample Collection	300	46,000
Labor - Year 2		
Study Design, Stakeholder Engagement	170	25,000
Stormwater Sample Collection	300	46,000
Data Technical Services		43,000
Analysis and Reporting	370	60,000
Subcontracts		
Stormwater CECs: Kolodziej, U. Washington		35,000
PFASs: Higgins, Colorado School of Mines		30,000
Phosphate Flame Retardants: Chen, Jinan U.		35,000
Ethoxylated Surfactants: Ferguson, Duke U.		30,000
Direct Costs		
Equipment		3,000
Travel		4,000
Shipping		20,000
Grand Total		395,000

Reporting

Deliverables will include: a) draft manuscripts[1] that serve as RMP technical reports, due spring 2021; b) a summary for managers describing the results and their implications, due spring 2021; and c) additions to other RMP publications such as the Pulse.

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Special Study Proposal: Small Tributaries POC Loading Program Management

Summary: The goal of the Small Tributaries Loadings Strategy (STLS) Program 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 and Hg sources, concentrations, loads, and the determination of trends in relation to management efforts and beneficial uses in San Francisco Bay. To support the Small Tributaries POC stormwater concentration and loading program, the outcome of this task will be to maintain monthly communication with BASMAA program and Water Board representatives. This will be completed through regular check in phone calls, planning for and development of meeting agendas and materials, preparation of meeting summaries, and monitoring the agenda of and attendance at key external meetings.

Estimated Cost: Option 1: $40,000
Oversight Group: STLS/SPLWG
Proposed by: Jing Wu, Lester McKee, Alicia Gilbreath, Jennifer Hunt (SFEI)

Proposed Deliverables and Timeline

Task	Deliverable	2019											
		J	F	M	A	M	J	J	A	S	O	N	D
A	STLS Management	!	!	!	!	!!	!	!	!	!	!	!	!

! = STLS check in for review and course corrections
!! = STLS/SPLWG oversight and review

Background

The San Francisco Bay Hg and PCBs TMDLs call for a reduction in loads by 50 and 90% by 2028 and 2030, respectively. In response, the first Municipal Regional Permit for Stormwater (MRP) Provision C.8.f. (SFRWQCB, 2009) 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 loads of sediments and trace contaminants 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. These same needs were reflected in the small tributary loading strategy (STLS) (SFEI, 2009). On November 19, 2015 the second MRP was issued and provided an updated set of management questions (provided below) (SFRWQCB, 2015).

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 back 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. These objectives help to ensure quality planning and implementation of projects that aim to answer the following five management questions:

MRP 2.0 Q1: Source Identification / Leverage: Which sources or source areas provide greatest opportunity for load reductions?
MRP 2.0 Q2: Impairment: Which source areas contribute most to impairment of Bay?
MRP 2.0 Q3: Management effectiveness: Provide support for planning future management actions or evaluate existing actions.
MRP 2.0 Q4: Loads: Assess POC loads, concentrations, or presence/absence.
MRP 2.0 Q5: Trends: What are the spatial and temporal trends in loads or concentrations?

Approach

RMP staff will provide management of the STLS process and STLS projects. Tasks include:

- Monthly meetings (phone calls)
- Quarterly or as needed face-to-face meetings
- Planning for and development of meeting agendas and materials
- Preparation of meeting summaries, and
- Monitoring the agendas of, and attendance at key external meetings (e.g. BASMAA Monitoring / POC Committee meeting, BASMAA BoD meetings)

Reporting

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

Linkages to other RMP Workgroups

RMP staff aim to help transfer information between other RMP workgroups and committees and the STLS and SPLWG. These include meetings of the Priority Margin Units (PCB Workgroup) and the Emerging Contaminants Workgroup (ECWG).

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Questions to SPLWG

Proposal 1: Reconnaissance characterization monitoring

- Are we ready to shift to remote samplers?
  - Do we need more testing of remote samplers?
  - Do we move to extended “super-remote” method?
- How can we adapt/refine these “reconnaissance” methods for broader uses (e.g., in watershed or regional models)?

Proposal 2: Advanced data analysis

- Do you have suggestions for improvement of the watershed scale site intercomparison method?
  a. Does the hypothetical basis for the method make sense?
  b. Are there ways of improving the parameter estimation (rainfall, runoff, land use) used for the normalization procedure?
  c. Does the congener profiling method hold promise and how it could be improved and applied?
- Do you have suggestions for improvement of the nested (sub-watershed scale and source property scale) intercomparisons?
  a. Based on mass
  b. Based on congeners
- Do you think the statistical approach holds promise and should be further explored next year?

Proposal 3: Regional model development to support trends strategy

- Are the trends strategy and multi-year plans pointing in the right direction?
- Are the priorities in alignment (timeline, effort & budget allocation, etc)?
- Are we missing anything important?

Proposal 4: CECs stormwater screening

- Are there other CECs that should be included in the monitoring effort?
- Are there other factors we should consider when selecting sites?
- What level of engagement or assistance can stormwater management agencies provide, particularly during the second phase of sample collection?