Sources, Pathways, and Loadings Workgroup: Five-Year Workplan (2008-12)

Lester McKee
John Oram
Don Yee
Jay Davis
Meg Sedlak

San Francisco Estuary Institute

SFEI Contribution xxx
Draft April 2008

6. SPLWG PRIORITY MANAGEMENT QUESTIONS (LEVEL III)

In 2000, the SPLWG developed a broad course of investigation (Davis et al., 2000) (Table 4), that built on the workplan presented in the first report of the SPLWG (Davis et al., 1999-2001). At that time, the management questions focused on improving estimates of loads from the main pathways, essentially paralleling the needs of the Hg and PCB TMDLs in development from 2000 to present (Looker, 2006; Hetzel, 2007). Although these guiding principles remain largely valid today for emerging contaminants, pyrethroids, dioxins, and most of the medium to lower priority contaminants, in the case of Hg and PCBs, , the SPLWG must now adapt to address questions associated with the implementation and monitoring recommendations sections of the PCB and Hg TMDLs and resulting Basin Plan amendments. Focus areas include source identification, BMP effectiveness, and concentration and loading trends. Fortuitously, these focus areas were listed as the last step of the workplan described in the first report of the SPLWG (Davis et al., 2001). In the specific case of stormwater management, these focus areas are reflected in the municipal regional permit tentative order (RWQCB, 2007).

Table 4. of the broad course of investigation followed by the Sources Pathways and Loadings Workgroup (Davis et al., 2000).

A. **Watershed Characterization**: Characterize and classify the watersheds in the region with regard to factors that control stormwater transport of priority contaminants.
B. **Conceptual Model Development**: Develop conceptual models for the generation, distribution, transformation, transport, and effects of classes of priority contaminants.
C. **Develop Evaluation Strategies**: Design and implement appropriate evaluation strategies for classes of contaminants with similar properties.
D. **Establish Regional Network of "Observation Watersheds"**: Carefully select representative "Observation Watersheds" for detailed, long-term evaluation of stormwater loading and related functions.
E. **Extrapolate to Other Watersheds**: As appropriate, extrapolate results from the Observation Watersheds to other watersheds with similar characteristics.

For the next five years covered by this workplan (2008-12), the highest priority management questions for the SPLWG are essentially those of RMP Question 3 and are consistent with a continued focus on quantifying the magnitude of loads from the main pathways, while at the same time assisting with source identification, BMP effectiveness, and concentration and loading trends. The SPLWG Level III questions are outlined below organized by pathway, in a logical order from a scientific point of view but not presently in order of priority from a management standpoint.

Small Tributary Loads

Level III SPL Question 1: How and where do contaminants enter the Bay from urban areas adjacent to the Bay margin?

There are two remaining data gaps in the effort to map rivers, creeks, storm drains and watershed boundaries: 1. Maps are still needed on the Bay margin for southern portions of Marin County (Sausalito, Mill Valley, Tiburon, Corte Madera, San Rafael, and Novato), Vallejo, Fairfield/Suisun, Benicia, Hercules, Rodeo, Crockett, Martinez, Concord, Pittsburg, and Antioch (Appendix 1 Maps 17, 18, 24, 25, 26, and 27), and 2. GIS line work needs to be attributed with additional data including flow routing (priority) and pipe dimensions and type (roughness). The workgroup is supportive of this work, recognizing needs in relation to measuring and estimating water, suspended sediments, and contaminant loads to the Bay, proving map tools for community outreach (the original intent of the effort when it was instigated in the early 90s), and tracking illicit discharge.

Level III SPL Question 2: What is the watershed-specific and regional total water flow, load of sediment, and load contaminants entering the Bay from the urbanized small tributaries and non-urban areas draining to the Bay from the nine-county Bay Area and are there trends through time?

Given, the Hg TMDL calls for reduction of loads on a watershed basis (Looker and Johnson, 2004), the PCB TMDL called for a 95% load reduction in watersheds, and the

Municipal Regional Permit (MRP) calls for better quantification of loads of sediments and trace contaminants on a watershed basis and regionally, a fundamental data gap is an estimate of flow at the scale of single watersheds. Given the lack of resources for gauging the more than 250 urbanized watersheds mapped to-date that drain to the Bay from the nine surrounding counties, modeling runoff appears to be the most cost-effective solution. The TRC has approved a special study for 2008 to develop a calibrated hydrological model for Guadalupe River, the first step towards a regional model.

An important remaining gap in knowledge is the relative mass of suspended sediment supplied from urban versus non urban areas of Bay Area small tributaries since this is presently the basis for the small tributaries loading component of the Bay Hg TMDL (see the Hg section). Looker and Johnson (2004) made the assumption that sediment loads are presently about 410,000 metric tonnes for urban areas. Given the urbanized area is about 2500 km^2, this equates to 164 t/km^2 (reasonable compared to international urban literature: McKee et al., 2003). However, Looker and Johnson's estimate of sediment loads from non urban areas (400,000 t) equates to 96 t/km^2. Given sediment loads measured in Bay Area watersheds by the USGS over the past 47 years show a range from 27 – 1,639 t/km^2 (see McKee et al., 2003), it seems reasonable to suppose non-urban loads for the Bay Area average much more than 96 t km^2. Furthermore, if a hypothesis that atmospheric deposition has been underestimated is accepted, it is possible that our current estimate of urban and non-urban runoff loads is biased low. The Technical Review Committee (TRC) of the RMP has approved funding for a special study in 2008 to update estimates for small tributaries and make estimates of urban versus non-urban loads for specific watersheds. Improved knowledge of suspended sediment loads will help us to better understand the rate of recovery towards contaminant related beneficial uses (swimmable, fishable, wild), future form and function of the Bay, and the supply of sediment to wetlands.

In terms of contaminants, there is still a number of remaining data gaps. One of the largest uncertainties in the Hg TMDL is a lack of empirical measurement of stormwater total Hg loads. Given the call for a 50% load reduction, this is an important data gap. Given the RMP Hg strategy focuses on a need to generate better information on MeHg, where budgets allow, data on MeHg should also be generated. Without any local data supporting the use of Hg-R as a surrogate for the movement of MeHg into the food web, Hg-R data will only be collected as part of an ancillary data set. Presently our estimates of regional PCB loads are based on measurements in mixed land use watersheds; data gaps include industrial watershed PCB loads and there is evidence to suggest the non-urban PCB loads are underestimated. For example, if the estimate of non-urban PCB loads including in the Bay TMDL (0.1 kg) is divided by the estimate of non-urban water flow (640 million m^3), an estimate of 160 pg/L is generated for a non-urban flow-weighted mean concentration. A quick scan of the recent PCB literature did not yield any papers on near urban non-urban systems but concentrations found in the Coyote Creek on the non-urban part of the hydrograph ranged between 2000-6000 pg/L during small storms in WY 2005. For PBDEs, given the recent decision to ban the use of Penta- and Octa-BDEs in California by June 2006 (voluntary withdrawal beginning in 2004), it is possible that a downward trend in many of the pathways may begin to occur over the next decade. However, it is possible that an increase in the Deca formulation may counteract the benefits of the ban, since some of the degradation products of Deca-BDE are similarly toxic. Further data are needed to observe any trends. With the exception of PBDEs, there are presently no measurements of emerging contaminant loads (e.g., pyrethroids, and perfluorinated compounds) and we have no measurements of dioxins. Until dynamic numeric modeling of urban and non-urban storm water can be completed, sediment load information will continue to provide the basic data for estimation of sediment-associated contaminant loads.

Level III SPL Question 3: What is the long-term average and maximum load of Hg (total, methyl and reactive) entering the Bay from the Guadalupe River and is there an observable trend?

There remains much uncertainty in the loads entering the Bay from Guadalupe River, including an understanding of the magnitude, sources, and speciation of loads during very large rainstorms. A reasonable hypothesis for the system is that in excess of 1,000 kg Hg may enter the Bay during rain events of 20-50 year return interval. James Rytuba of USGS estimates that there is approximately 30,000 kg of Hg still to be released from the mining areas. At the current rate of loss, this represents 200 years of Hg load. In addition, given the TMDL call for a large load reduction in the Guadalupe River, it will be important to determine effectiveness. One method would be to monitor for loading trends at our monitoring location (Hwy 101: USGS gauge number 11169025). Given Guadalupe TMDL asked for large total Hg load reductions, it would seem likely that trends in concentrations and loads will be observable over the next decade despite the water column concentration dataset containing a complex urban and mining signal. At present there has not been any attempt to determine the size of the load reduction necessary to see a trend in concentration.

Central Valley Loads

Level III SPL Question 4: What is the magnitude of contaminant loads entering the Bay from the Central Valley and is there an observable trend?

There are a number remaining questions including improving knowledge on Hg loads during large floods and determining if there is a trend in mercury loading. There have been no measurements of MeHg or reactive Hg during floods but until information is improved on the way MeHg is getting into the food web (deamed high leverage pathways) it is not clear if this information is needed. In the case of PCBs, further work is required to better understand the cause of high concentrations and loads observed during smaller floods. In direct contrast to Hg, the present hypothesis is that PCB concentrations and loads may be diluted during large runoff events when the majority of water is derived from less urbanized non-Valley flood watershed and snow melt. A re-analysis of congener patterns during floods with differing runoff sources and magnitudes, and a calculation of a new long term loading estimate is planned for calendar year 2010 after the collection of another wet season of data. With the exception of PBDEs, there are presently no measurements of emerging contaminant loads (e.g., pyrethroids, and perfluorinated compounds) and we have no measurements of dioxins. Again, the SPLWG needs to look to the CFWG for guidance on how much effort to put into gathering this information. The question of trends is different for the Mallard Island sampling location compared to the Guadalupe River sampling location. In the Sacramento River at Mallard Island, any trend observed is more likely to be associated with the declining loads of suspended sediment rather then a change in the management of Hg or PCBs. It is not clear conceptually how particle concentrations will change as suspended sediment concentrations decrease.

Atmospheric Deposition Loads

Level III SPL Question 5: What is the magnitude of loads of contaminants entering the Bay from local air sources?

Recently Dr. Sarah Rothenberg (post doc with SFEI) has been reviewing the potential for further improvements in source control to reduce urban runoff loads. She conducted a thorough review of all local data including monitoring and estimates of air emissions by the California Air Resource Board (CARB) based on "emissions factors". Her work supports the following points:

1. The Bay Area has the largest predicted unit area emissions in the State (15$\mu g/m^2$),
2. Three source categories (five oil refineries, one cement plant, and 45 crematoriums) make up 98% of the estimated air sources,
3. Deposition is estimated at 233 kg of which more than 40% is expected to deposit locally, and
4. Atmospheric sources of Hg may represent potential hotspots which may be mitigated through emission controls

Research in other systems provides evidence that newly deposited Hg through atmospheric deposition is more readily converted to MeHg, and biomagnified in the food web, than "native" Hg (Harris et al., 2007 and references therein). A key data gap is to determine if this is true for the Bay Area. To do this we would need to determine the magnitude, speciation, and fate of atmospherically derived Hg from local sources in the Bay Area a key positions in the food web. The aerial estimates of PCB loads by Tsai et al. (2002) are considerably lower than the estimate for urban United Kingdom by Harrad (1994) (310 $\mu g/m^2/y$). A study completed in Paris reported a dry deposition of 29 $\mu g/m^2/y$ and that dry deposition only accounted for 35% of the total deposition of PCBs (Granier and Chevreuil, 1997). A study in Switzerland found a dry deposition of 1.06 $\mu g/m^2/y$ (Rossi et al., 2004). Apparently, a ratio of 2:1 wet : dry is common but others have used a ratio of 10:1 (see references in Granier and Chevreuil, 1997) or even 12:1 (Rossi et al., 2004). Based on this quick literature review, it appears our local estimates of PCB deposition are anything from 0.1% to 33% of those reported elsewhere. It seems reasonable to hypothesize that Bay Area loads have been underestimated perhaps because the sampling location was chosen to try to reflect general background loading; local air sources such as landfills, industrial fires, recyclers, and auto shredders may provide additional local loads that are presently not taken into account. The magnitude of dry and particularly wet PCB deposition to the Bay has important implications for management and recovery of the Bay and may be a critical data gap. With the exception of PBDEs, there are presently no measurements of emerging contaminant loads (e.g. pyrethriods, and perfluorinated compounds) and we have no measurements of dioxins.

Municipal and Industrial Wastewater Loads

Level III SPL Question 6: What is the magnitude of loads of contaminants entering the Bay from industrial and municipal wastewater and are they showing trends through time?

In general, measurements are relatively robust for total Hg, PCBs, and PBDEs. Methylmercury data has been collected by BACWA but as yet a regional estimate of MeHg loads is not available. Remaining data gaps include reactive Hg and there are presently no measurements of emerging contaminant loads (e.g. pyrethriods, and perfluorinated compounds) and we have no measurements of dioxins.

In-Bay Bed Sediment Loads

Level III SPL Question 7: What is the magnitude of flux of MeHg and reactive Hg from sediment in each Bay segment?

Presently there are only measurements of MeHg flux from bottom sediments in the South Bay segment. Topping et al. (2004) quantified dissolved mercury fluxes to the water column from bottom sediments. The study results from three locations, when extrapolated for the entire South Bay supported the conclusion that dissolved fluxes to the South Bay water column may be of the same magnitude as annual inputs from the Guadalupe River watershed. With the increase in focus of the RMP on MeHg and reactive Hg, there are several critical questions that remain in relation to benthic production of these Hg species. Are the measurements so far made typical of San Francisco Bay as a whole or are there differing flux rates between segments and in the inter-tidal zone, shallow sub-tidal zone, and the Bay axis? Do fluxes of MeHg and reactive Hg from bottom sediments disproportionably influence the base of the food web? The reintroduction of mercury and the release of bioavailable forms of mercury from legacy sediment remains an important area of uncertainly and a potential hurdle for the recovery of the Bay despite the called for load reductions from the Guadalupe River and urban stormwater pathways. Either the SPLWG or the CFWG may consider prioritization of this question.

7. SPLWG FIVE-YEAR WORKPLAN

Table 5. SPLWG 5-year workplan.

			Year					
Element	Description	Funder/Program	08	09	10	11	12	MQs Addressed
*Workgroup meetings			25	25	25	25	25	
*SPLWG expert review and meeting attendance			6	6	6	6	6	
*Five-year plan maintenance			3	3	3	3	3	
Subtotal			***34***	***34***	***34***	***34***	***34***	
Small tributaries loading (Observation watershed No 2)	Focus on wet weather with some dry weather	RMP (S&T)	150	100				3A. Which sources, pathways, and processes contribute most to impacts? 3B. What are the best opportunities for management intervention for the most important contaminant sources, pathways, and processes? 3C. What is the effect of management actions on loads from the most important sources, pathways, and processes?
Small tributaries loading (Observation watershed No 3 to be determined)	Focus on wet weather with some dry weather	RMP (S&T)			150	100	100	3A. 3B. 3C.
Mallard Island large rivers loading study	Wet weather sampling to determine concentrations and loads	RMP (S&T)			140*			3A. 3B.
Small tributary suspended sediment loads	Static sediment load estimates for specific watersheds and for urban versus non-urban	RMP (P&SS)	40					3A.
Guadalupe River Model	Refine loading estimates, source attribution, and predicting BMP effectiveness	RMP (P&SS) (Note only first year funded presently)	75					3A. 3B. 3C.
Small tributaries loading (Observation watershed No 1: Guadalupe River)	Focus on wet weather with some dry weather	RMP (S&T) (Note perhaps 5 years of funding for Hg from SCVWD)			65*			3A. 3B. 3C.
To be determined based on SPLWG priorities	????	RMP (P&SS)		100	100	100	100	????
Subtotal			***265***	***200***	***455***	***200***	***200***	
Total			**299**	**234**	**489**	**234**	**234**	

* Every three years